

Public Health Assessment for

Stauffer (Tarpon Springs)
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STAUFFER CHEMICAL COMPANY (TARPON SPRINGS)
TARPON SPRINGS, PINELLAS COUNTY, FLORIDA
EPA FACILITY ID: FLD010596013
APRIL 2, 2003

FOR PUBLIC COMMENT

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry



Comment Period Ends:

JUNE 3, 2003



THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment program allows the scientists flexibility in the format or structure of their response to the public health issues at hazardous waste sites. For example, a public health assessment could be one document or it could be a compilation of several health consultations the structure may vary from site to site. Nevertheless, the public health assessment process is not considered complete until the public health issues at the site are addressed.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further public health actions are needed.

Conclusions: The report presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high risk groups (such as children, elderly, chronically ill, and people engaging in high risk practices), they will be summarized in the conclusion section of the report. Ways to stop or reduce exposure will then be recommended in the public health action plan.

ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, fullscale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Chief, Program Evaluation, Records, and Information Services Branch, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E60), Atlanta, GA 30333.

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LIST OF ABBREVIATIONS

ACFM	actual cubic feet per minute
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	asbestos-containing materials
ACS	American Cancer Society
ATSDR	Agency for Toxic Substances and Disease Registry
B	Detected in the associated laboratory blank and in the sample
bgs	below ground surface
bls	below land surface
Bq/kg	becquerels/kilogram
C-EMEG	chronic environmental media evaluation guide
CAT	computed axial tomography
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
COPD	chronic obstructive pulmonary disease
CRDL	contract-required detection level
CREG	cancer risk evaluation guide
CTD	conductivity, temperature, and depth
CVs	comparison values
EE&G	Evans Environmental & Geological Science and Management, Inc.
EGR	external gamma radiation
EMF	Eastern Michaud Flats
EPA	U.S. Environmental Protection Agency
ERG	Eastern Research Group
ESI	expanded site investigation
f/cc	fibers per cubic centimeter
FCDS	Florida Cancer Data System
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FFWC	Florida Fish and Wildlife Conservation Commission
GES	Gulfside Elementary School
HEI	Health Effects Institute
HRS	hazard ranking system
HSCS	Harvard Six Cities Study
HSL	hazardous substance list
I	approximate value between the detection level and quantitation level
I-EMEG	intermediate environmental media evaluation guide
EP	environmental pollutants
FDER	Florida Department of Environmental Regulation
ICRP	International Committee on Radiation Protection
ISCST3	Industrial Source Complex, Short Term
J	Estimated quantity below the quantitation limit
LOAEL	lowest-observed-adverse-effect level
LTHA	lifetime health advisory

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m/s	meters per second
m ³ /s	cubic meters per second
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg/kg/day	milligrams chemical per kilogram body weight per day
mg	milligrams
mg/m ³	milligrams per cubic meter
MRL	minimal risk level
N	presumptive evidence of presence of material
N-2-N	Neighbor-2-Neighbor
NA	not available
NAAQS	National Ambient Air Quality Standards
NCDC	National Climatic Data Center
NCRP	National Council on Radiation Protection and Measurements
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety and Health
NMMAPS	National Morbidity, Mortality, and Air Pollution Study
NOAEL	no-observed-adverse-effect level
NPL	National Priorities List
NSDWRs	National Secondary Drinking Water Regulations
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PBS&J	Post, Buckley, Smith and Jernigan
PCBs	polychlorinated biphenyls
PCDEM	Pinellas County Department of Environmental Management
pCi/g	picocuries per gram
pCi/L	picocuries per liter
PCM	phase contrast microscopy
PHAP	public health action plan
PM ₁₀	particulate matter less than 10 micrometers in diameter
PM _{2.5}	particulate matter less than or equal to 2.5 micrometers in diameter
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
RBC	risk-based concentration
RBC-C	risk-based concentration, for cancer effects
RBC-N	risk-based concentration, for noncancer effects
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RMEG	reference dose media evaluation guide
SALP	synthetic precipitation leaching potential
SCC	Stauffer Chemical Company
SFWMD	Southwest Florida Water Management District
SIR	standardized incidence ratio
SMC	Stauffer Management Company

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STEL	short-term exposure limit
SVOCs	semivolatile organic compounds
T	compound tentatively identified by laboratory during analysis
TAL	target analyte list
TCL	total compound list
TCLP	toxicity characteristic leaching procedure
TEM	transmission electron microscopy
TLV	threshold-limit value
TOC	total organic carbon
TSP	total suspended particulates
TWA	time-weighted average
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
VOCs	volatile organic compounds
X	result is less than the CRDL, but greater than or equal to the instrument detection limit
$\mu\text{g/kg/day}$	micrograms chemical per kilogram body weight per day

EXECUTIVE SUMMARY

This public health assessment for the Stauffer Chemical Company (Stauffer) site in Tarpon Springs, Florida, is in response to recommendations from the December 2000 *Ombudsman Report of Findings and Recommendations Regarding the Stauffer Chemical Company Site, Tarpon Springs, Florida*. The report recommended that the Agency for Toxic Substances and Disease Registry (ATSDR) prepare a new public health assessment to more thoroughly address community concerns about the site.

The Stauffer site is ½-mile south of the Pasco-Pinellas county line and 1.6 miles east of the Gulf of Mexico. From 1947 to 1981, the 138-acre site operated as a chemical plant that extracted elemental phosphorus from phosphate ore. The facility included a phosphate ore processing area, elemental phosphorus production facilities, a slag processing area, and a system of settling ponds. Residual wastes from the operation were disposed in on-site settling ponds and in the slag processing area, both of which are groundwater contamination sources.

According to 1980 Census data, almost 6,000 people lived within 1 mile of the site. Approximately 9,200 people lived within 1 mile of the site according to 2000 Census data.

The major surface water in the site area is the Anclote River. The river is primarily used for recreation, including boating and swimming, and support of wildlife.

A. Environmental Contaminants

Following are summaries of data from site sampling investigations and monitoring programs. More information on these summaries can be found in the Environmental Contamination and Other Hazards section of this document. ATSDR reviewed the environmental data and selected contaminants warranting further evaluation based on (1) the adequacy of the sampling conducted, (2) the maximum concentration and frequency of detection of the contaminants found in various media, (3) comparison of the maximum detected concentrations with health-based screening values, also known as comparison values (CVs).

- ▶ ***On-site soil/slag samples contained arsenic, cadmium, thallium, fluoride, and radium-226 at concentrations that exceed ATSDR's comparison values (CVs).*** On-site surface soil samples from two locations also contained asbestos at very low levels.
- ▶ ***Groundwater samples from the shallow aquifer (on-site) contained a number of contaminants at levels that exceed ATSDR CVs.*** These contaminants include aluminum, antimony, arsenic, boron, cadmium, chromium, fluoride, iron, lead, lithium, manganese, mercury, nickel, selenium, thallium, vanadium, sulfate, gross alpha, radium-226, and radon-222.
- ▶ ***Groundwater samples from the Floridan Aquifer (on-site) contained few contaminants at concentrations in excess of ATSDR CVs.*** Site-related contaminant concentrations were generally lower in the Floridan Aquifer than in the surficial aquifer, although similar concentrations of arsenic and fluoride were reported in nested wells

MW-9S and MW-3F, which are on the river shore down gradient of the main production area.

- ***Some private (residential, commercial, and irrigation) water supply wells sampled contained arsenic, chromium, lead, nickel, thallium, zinc, chlorides, sulfate, gross alpha radiation, and radium-226 at levels above ATSDR CVs. However, these contaminants were detected infrequently and most were at concentrations no more than 10 times higher than CVs.*** Identified private wells are not in the direct path of flow of site groundwater contamination; therefore, the source of the few detected elevated levels is not known, but may be due to naturally occurring background. Thirty-eight private wells (residential potable, commercial potable, and irrigation wells) in the site vicinity have been sampled since 1988.

Residential and commercial wells are believed to draw water from the Floridan Aquifer. Irrigation wells draw water from the surficial (shallow) aquifer, but are not used for drinking water purposes.

Note: Public water supplies are not in the path of known contaminant migration and, as such, have not been affected by the Stauffer site.

- ***Surface water samples (from the Anclote River) contained the following contaminants at levels above drinking water CVs at least once: antimony, arsenic, boron, chromium, iron, lead, thallium, vanadium, fluoride, sulfate, gross alpha and beta radiation, and radium-226.*** Contaminants detected and for which no CVs are available include calcium, magnesium, sodium, phosphorus, and polonium-210.

Arsenic, boron, and sulfates were consistently detected at levels above CVs throughout the river. Gross alpha and beta radiation levels are similar both upstream and in Meyers Cove, but radium-226, radon, and polonium-210 are at least three times higher in Meyers Cove than in areas immediately upstream.

- ***Sediment samples (from the Anclote River) contained arsenic, thallium, fluoride, radium-226, polonium-210 at levels that exceeded CVs at least once.*** The highest concentrations of these contaminants were generally detected (a) in Meyers Cove and (b) during the 1988 and 1989 sampling events.

Detected concentrations of metals, although generally below CVs, were elevated above background near the site, particularly in Meyers Cove. The highest concentrations of aluminum, arsenic, barium, chromium, silver, and vanadium were detected at Meyers Cove. Arsenic, however, was the only substance consistently detected at levels above its CV. Levels of phosphorus and total organic carbon (TOC) are also highest at Meyers Cove and areas adjacent to the site (just upstream of Meyers Cove) compared to upstream and downstream locations. Likewise, gross alpha and beta radiation were measured at the highest levels in Meyers Cove and adjacent to the site (up to 50 times higher activity than in upstream samples). Radium-226 and polonium-210 were only

detected in Meyers Cove and adjacent to the site, but detected concentrations just slightly exceeded CVs.

- ▶ ATSDR contacted the Florida Department of Environmental Protection, Florida Department of Health, Florida Fish and Wildlife Conservation Commission, and Florida Marine Research Institute to identify available fish tissue and shellfish sampling data. **No fish or shellfish sampling data were identified in the site area.**

B. Completed Exposure Pathways

ATSDR identified the following completed exposure pathways for the Stauffer site:

- ▶ ***Breathing outdoor air is a completed past exposure pathway—both on-site and off-site.*** When the plant was operational, area residents noticed “haze” and dusts presumed to be emitted from the plant furnace. Residents also expressed concern about emissions during site activities involving digging or excavations, particularly slag processing activities. **People working at or living near the Stauffer site during those times were exposed to airborne contaminants emitted from various plant operations and site activities.**
- ▶ ***Drinking on-site groundwater is a completed exposure pathway (past) for the Stauffer site.*** Groundwater was used for drinking and industrial purposes on-site until approximately 1979. Drinking water was drawn primarily from wells within the deeper Floridan aquifer. Available data show that measured contaminant levels did not exceed health-based CVs in the wells known to have been used for drinking water purposes. The site is now served by public water. Nearby public water supplies have not been affected by the Stauffer site.
- ▶ ***Contacting on-site surface soil and slag is another completed exposure pathway (past).*** Contact with on-site soils and slag by the general public or by trespassers is expected to be minimal because the site is completely fenced with 24-hour security. Past plant and remediation workers might have had a greater opportunity to contact contaminated materials. It is not known how much soil and slag people might have come in contact with in the past. Completed and planned clean-up actions are intended to eliminate or prevent possible future exposures. The site is now completely fenced, preventing public access.
- ▶ ***Contacting off-site soil (at Gulfside Elementary School) is also a completed pathway.*** Because of its proximity to the Stauffer site and the fact that children would be an affected population, several studies have focused on characterizing the soils and building materials on the Gulfside Elementary School property. Other than radium-226, no contaminants were detected at elevated levels in school soils. No other off-site soil data are available.

- ▶ ***Contacting off-site slag/building materials is also a completed exposure pathway.*** Slag generated by Stauffer processes was stored on-site and used as roadway and building material throughout nearby communities. It is not known how much direct contact people have had with slag in these areas, but sampling results show relatively low contaminant concentrations (compared with on-site conditions). External gamma radiation exposures associated with these materials also were measured and determined not to be harmful.
- ▶ ***Ingesting and contacting surface water and sediment (in the Anclote River) are completed exposure pathways because contaminated groundwater from beneath the Stauffer site discharges to the river and people might come in contact with water and sediment when using the river.*** The river is used for boating, fishing, swimming, and wading. However, in general, water and sediment samples, especially those collected away from the site (e.g., downstream locations sampled near the mouth of the river) do not show unusually elevated contaminant levels. The highest detected contaminant concentrations in sediment were found in Meyers Cove. In addition, ingestion of surface water contaminants is likely to be minimal because the river is brackish and is not used as a drinking water source.

C. Potential Exposure Pathways

ATSDR identified the following potential exposure pathways for the Stauffer site:

- ▶ ***Drinking off-site groundwater is considered a potential exposure pathway (past, current, and future) because private wells tapping the deep aquifer have and continue to be used by some area residents and businesses for drinking and other purposes.*** Some nearby shallow groundwater wells are used for irrigation and lawn-watering activities. Available sampling data (1988–2002) show a few contaminants at slightly elevated levels in area private wells. The source of these contaminants, however, has not been linked with the Stauffer site.
- ▶ ***Eating fish and shellfish (biota) is a potential exposure pathway (past, present, and future).*** Although the site-related contaminants found in water and sediments are not generally expected to build up in fish, no testing of Anclote River fish and shellfish tissue has been done to lend support to this premise, despite recommendations by past investigators to conduct benthic studies and metal analysis in fish tissue.

D. Conclusions

ATSDR reached the following conclusions on the basis of ATSDR's evaluation of available site information and sampling data.

1. Current Exposures

The Stauffer Chemical Company Site is currently not a public health threat because people are not being exposed to contaminants from the site at unsafe levels.

i. Current Air Exposures

The levels of TSP, PM₁₀, and PM_{2.5} were reduced after 1981 when the Stauffer plant stopped operating. **Since 1981, the estimated and measured levels of particulate matter in the general vicinity of the former Stauffer plant, and subsequent risk of an adverse heart and lung health outcome, were similar to those in many areas of Florida and the United States.**

Current levels of sulfur dioxide in air are not likely to cause harmful effects in people, including people with asthma.

Results of air sampling conducted by EPA in the 1990s for fluorides show it is unlikely that fluoride is being released to the air at harmful levels.

ii. Other Current Exposures

The concentrations of radionuclides measured at Gulfside Elementary School do not pose a health hazard to students or staff.

2. Historical (Past) Exposures

i. Air Exposures Before 1982

Levels of air pollution in the immediate area of the Stauffer facility while it was operating were likely to be a public health hazard because of the combined emissions from the Stauffer facility and from other sources in the area. The components of air pollution causing the health hazard are sulfur dioxide and particulate matter. These components reached levels that in the scientific literature were associated with an increased incidence of adverse lung and heart conditions. Populations at greatest risk for suffering adverse health effects include children, the elderly, persons with preexisting heart or lung disease, and persons with asthma who lived or worked near the Stauffer facility. In making this hazard determination, some uncertainty exists in the health conclusions for long- and short-term exposures to particulate matter and long-term exposure to sulfur dioxide. However, both sulfur dioxide, as well as particulate matter, are likely to affect the lungs; therefore, any added particulate matter exposures in combination with sulfur dioxide exposures may have increased the risk of an adverse effect to the lungs. Specific perspective on the public health implications of exposure and uncertainty of exposures to sulfur dioxide and particulate matter follow.

Short-term and long-term exposure to particulate matter

Particulate matter is ubiquitous both in outdoor and indoor environments. Besides the multiple outdoor sources of PM exposures to the community (including the Stauffer facility, the Florida Power Anclote Plant, automobiles, and others), there are numerous other indoor sources of PM exposures from cooking, cleaning, and other indoor activities. The sampling data quite clearly demonstrate that air emissions when the Stauffer facility was active caused increases in particulate matter concentrations near the facility. However, the particulate matter levels measured near Stauffer between 1977-1981, though greater than Florida's previous air quality standards, were similar to particulate matter levels routinely measured in many suburban and urban settings throughout the state. When ATSDR evaluates exposure to environmental contamination, our primary role is to examine whether exposures are at levels associated with adverse health effects. Whether or not other populations experienced greater or lesser exposures does not factor into our public health evaluations for a given site.

ATSDR relied on the vast epidemiological evidence that strongly suggests that short- and long-term exposure to particulate matter is associated with adverse lung and heart diseases. Specifically, the scientific literature has shown associations with very serious health effects (death) to less serious health effects (e.g., slight lung function changes). Based on our best estimates, particulate matter exposures from all sources and that attributable to Stauffer could have resulted in one of the adverse health effects shown in the scientific literature. Moreover, the population exposed to particulate matter attributable to Stauffer are more likely to have experienced the less serious health effects of lung and heart diseases and reductions in lung function than other more serious health effects reported in the literature. Although ATSDR provides this perspective for the community to better understand their risk of the most serious adverse health effect, we do so with some uncertainty. Given that the exposed population may have had a higher percentage of elderly (a likely sensitive population), ATSDR cannot completely rule-out any of the adverse health effects that have been associated with PM exposures. In any case, the risk of an adverse cardiopulmonary health outcome was likely reduced once the Stauffer facility ceased operation in 1981 because the levels of exposure to particulate matter, especially the smaller, fine, particles were lowered.

Persons residing in or working in the following areas might have experienced adverse health effects similar to those reported in the literature from their exposures to particulate matter:

- The Flaherty Marina (before 1982),
- Residential homes built before 1982 southwest of the Stauffer facility along the shore of the Anclote River,
- Residential homes west of the Stauffer facility built before 1982 and within 1,540 feet of the kiln, and
- Commercial and industrial businesses east of the Stauffer facility along Anclote Road built before 1982 and within 1,540 feet of the kiln.

Short-term and long-term exposure to sulfur dioxide

Air monitoring data are available for 1977 to 1979 and most of the time sulfur dioxide levels were below ATSDR's health guideline of 10 parts per billion (ppb). Periodically, however, hourly sulfur dioxide levels at the Anclote Road monitoring station near the Flaherty Marina showed significantly elevated levels of sulfur dioxide. The highest average sulfur dioxide level detected in a one-hour monitoring period was 840 parts per billion (ppb). Because valid human studies are available concerning the harmful effects of sulfur dioxide, ATSDR is concerned about the times when sulfur dioxide levels were above 100 ppb, the lowest known level to cause a response in humans. The concern becomes greater at levels above 500 ppb.

People who lived, worked, or visited the following areas before 1981 when Stauffer was operating were at risk for harmful effects from exposure to sulfur dioxide based on hourly measurements.

These areas include:

- The Flaherty Marina,
- Residential homes southwest of the Stauffer facility along the shore of the Anclote River,
- Residential homes west of the Stauffer facility, and
- Commercial and industrial businesses east of the Stauffer facility along Anclote Road.

People who lived in these areas might have experienced the following harmful effects:

- changes in lung function (such as, an increase in airway resistance and a narrowing of lung's airways),
- wheezing and shortness of breath,
- an increase in heart rate and breathing rate,
- cough, and
- throat irritation.

It is important to remember that people who are most sensitive to the effects of sulfur dioxide are exercising asthmatics and that only at the highest hourly levels detected (600 to 800 ppb) will healthy (non-asthmatic) people experience some of the symptoms of sulfur dioxide exposure.

ATSDR used an air dispersion model to predict sulfur dioxide levels in the surrounding community for times when Stauffer had a major release of sulfur dioxide. This model predicted that significant sulfur dioxide levels moved into the surrounding community.

It is important to remember that exposure to relatively low levels of sulfur dioxide (for example, 100 ppb sulfur dioxide) is not likely to cause noticeable symptoms, such as wheezing or shortness of breath. At 100 ppb sulfur dioxide, only exercising asthmatics have shown responses and these responses were mild changes in the lung's airways (specifically, an increase in airway resistance). It should also be pointed out that the human studies conducted at 100 ppb had asthmatics breathe through a mouthpiece, thus increasing their exposure to sulfur dioxide. It is uncertain if exercising asthmatics would experience these mild effects on the lungs if they were exercising and breathing through their mouth and nose. It is also important to know that this increase in airway resistance is temporary and will return to normal shortly after exposure ends. However, as sulfur

dioxide exceed 500 ppb, some asthmatics will require medication to treat the symptoms of wheezing and shortness of breath.

Results of air monitoring at the Anclothe Road monitoring station and the air dispersion model showed that residents who lived in portions of Tarpon Springs, Holiday Estates, and surrounding areas were likely exposed for many years to elevated yearly sulfur dioxide levels. The sulfur dioxide levels are similar to levels shown in human studies to be associated with a small increase in mortality, particularly in people with pre-existing lung and heart disease. The increased risk of mortality existed while people were being exposed. Because of the low levels of exposure from 1977 to 1981, it is unlikely that people who were exposed in the past are currently at risk of harmful effects. Some uncertainty exists in these conclusions because the results are based on modeling information and some uncertainty exists in the human studies.

Exposure to fluoride

The limited number of air samples that measured for fluoride did not show fluoride to be a health concern. However, one of the historical air samples showed fluoride levels at Stauffer's fence line to be slightly above ATSDR's acute Minimal Risk Level (MRL). Irritant effects from brief exposures to the fluoride level detected seem unlikely because the detected fluoride level was far below the level that caused harmful effects. Firm conclusions, however, cannot be drawn because the sample averaged fluoride levels over 24 hours, which might have masked higher levels of fluoride in a migrating plume. In addition, too few air samples were taken for fluorides when the Stauffer facility was operating to determine what levels of fluorides were being released. ATSDR's modeling analysis, which was based on the best available emissions data, suggests that ambient air concentrations of fluorides did not exceed levels of health concern. Although this modeling analysis has limitations (most notably that emissions data were not available for every source at the facility), ATSDR is reassured by its previous evaluations of air quality issues at much larger elemental phosphorus production facilities, with very extensive air sampling data for fluorides, which showed no evidence of fluoride exposures at levels of health concern.

Exposure to Other Air Pollutants

Residents who lived near the Stauffer facility while it was operating were likely exposed to a number of additional contaminants in air (e.g., metals, phosphorus compounds, inorganic acids); however, the magnitude and impact of these exposures could not be evaluated from available site data and information.

Uncertainty in Health Conclusions About Air Pollutants

Some uncertainty exists in ATSDR's health conclusions, such as

- The accuracy of the estimated levels of PM_{2.5} for the 1970s and 1980s. Using the limited TSP data from 1977-1981, ATSDR developed our best estimate of what exposures to fine particulates may have been. The methods used and justifications

for developing these estimates are provided by ATSDR in the public health assessment.

- Some scientists believe that the associations found in epidemiological studies do not provide conclusive evidence that exposure to ambient levels of particulate matter and sulfur dioxide actually cause adverse cardiopulmonary health effects because a clear biological mechanism, among other things, has yet to be clearly established. While ATSDR acknowledges this uncertainty, based on the strong epidemiological evidence, we feel that a number of health effects were possible because of past exposures to Stauffer particulate matter and sulfur dioxide emissions.
- Some studies suggest that certain types of particulate matter may be more or less toxic depending on the size of the particles and the composition. ATSDR has no information to conclude that the particulate matter emitted from Stauffer was any more or less toxic than particulate matter that has been associated with adverse cardiopulmonary health effects in the scientific literature.
- The overall interpretation of the scientific inquiry into the health effects of particulate matter and sulfur dioxide. For example, some suggest that particulate matter and sulfur dioxide can be viewed as a surrogate indicator for the overall mixture of air contaminants, as a specific cause of health effects, or both. **Whatever the case, in general, ATSDR believes that reducing particulate matter and sulfur dioxide exposure would be expected to lead to reducing the frequency and severity of the health effects associated with exposure to particulate matter and sulfur dioxide.**
- The levels of particulate matter that are considered protective for all segments of the population. ATSDR's evaluation of the public health implications of exposures to particulate matter incorporates the understanding that no currently established "safe" levels of particulate matter exposure exist.
- The effects on the lungs caused by exposure to 100 ppb sulfur dioxide occurred in subjects who breathed through a mouthpiece while exercising. Whether or not the same effects would occur in subjects who breathed through their mouth and nose while exercising is uncertain. However, this and other effects were seen in subjects exposed in a chamber to higher levels of sulfur dioxide.

Review of Community Health Concerns about Past Stauffer Air Emissions

Some of the health concerns expressed by community members in relation to past air exposures related to the Stauffer facility (i.e., asthma, breathing problems, chronic obstructive pulmonary disease [COPD], and other nonspecific lung diseases) are reasonably consistent, with adverse health outcomes reported in the epidemiologic literature for both acute and chronic exposures to particulate matter (or sulfur dioxide). For asthma, it is important to note that the scientific

literature does not currently suggest that PM causes asthma but that it may exacerbate it. Moreover, there are other known and suspected factors that may trigger asthma. A list of these triggers can be found at <http://www.lungusa.org/asthma/astatrigger.html> and <http://www.lungusa.org/asthma/asctriggers.html>. The consistency between the community's health concerns and the epidemiologic studies does not suggest that a specific person's disease was caused by inhalation exposures to particulate matter. Rather, the cause of any disease is usually a result of multiple factors. For example, smoking is a strong risk factor for many lung and heart diseases. Therefore, smokers make up another population group likely at increased risk for particulate matter-related health effects (EPA 1996). ATSDR has not determined that any of these reported illnesses were elevated in the community in relation to exposures from Stauffer, but only that they are consistent with the findings from the scientific literature.

ii. Contaminants in Private Drinking Water Supplies

Two commercial wells and one private well near the Stauffer facility contained arsenic at levels that exceeded EPA's drinking water standard of 10 ppb. The elevated arsenic levels are not believed to be related to groundwater contamination beneath the Stauffer site. **It is unlikely that children or adults would experience noncancerous harmful effects from drinking water from these wells.** However, a small theoretical increase in the risk of cancer can be calculated should someone drink 8 glasses (2 liters) of water from these wells on a daily basis over a lifetime; however, the risk might also be zero. Uncertainty exists in deciding the risk of cancer because only one well sample is available; therefore, the concentration of arsenic in the well throughout someone's lifetime may vary. ATSDR's estimate of a small theoretical increase in the risk of cancer assumes a lifetime of exposure at the arsenic concentration in that one sample.

Four private wells near the Stauffer facility contained lead at levels that exceeded EPA's action level of 15 ppb. The elevated lead levels are not believed to be related to groundwater contamination under the Stauffer site. The highest lead level detected was 270 ppb. This level was detected only one time, which means that the people who used this well were probably only exposed for several months to lead. Lead levels 3 months before and 3 months after the high level were below EPA's action level. Brief exposures to 270 ppb lead in drinking water for a preschool child might cause changes in blood chemistry, mild effects to the liver, and, for boys, mild effects to the prostate. These effects are also likely for preschool children who used the well that contained 160 ppb lead. For the other two wells that contained 18 and 24 ppb lead, harmful effects are unlikely.

iii. Gulfside Elementary Students

ATSDR determined that two primary exposure pathways could have had an impact on children who attended Gulfside Elementary school from 1978–1981. The two exposure pathways are contact with soil and breathing outdoor air.

Soil sampling at the school showed elevated levels of radionuclides; however, the concentrations of radionuclides did not pose a health hazard at the levels measured. The elevated radionuclide levels may have been associated with wind-blown dust from the Stauffer slag processing and

loading operation which was located directly across the street from the school. Arsenic was also detected in soils at the school but not at levels of health concern. In addition, the amount of soil and dust that children in elementary school ingest incidentally during their daily activities is small. Therefore, adverse health effects from exposure of Gulfside Elementary students to contaminants in school soils would not be expected.

Air monitoring data showed that children could have been exposed for brief periods to high levels of sulfur dioxide on some days. However, on most days the wind came from a direction that would have blown the pollution away from the school. These intermittent exposure to high levels of sulfur dioxide might have caused the following symptoms in some children at the time of the exposure in 1978 to 1981: throat irritation, cough, wheezing, and shortness of breath. In addition to brief periods of exposure to high levels of sulfur dioxide, children who attended Gulfside Elementary School might have been exposed to sulfur dioxide for long periods. Results of air monitoring at the Anclote Road monitoring station and the air dispersion model showed that children and adults at Gulfside Elementary School were likely exposed for many years to slightly elevated yearly sulfur dioxide levels. The yearly sulfur dioxide levels are similar to levels shown in human studies to be associated with a small increase in mortality, particularly in people with pre-existing lung and heart disease. The increased risk of mortality existed while people were being exposed. Because of the low levels of exposure from 1977 to 1981, it is unlikely that people who were exposed in the past are currently at risk of harmful effects. The areas most impacted by Stauffer emissions are shown in Figure 27 and include the areas covered by the 10 ppb and 5 ppb contours. Some uncertainty exists in these conclusions because the results are based on modeling information and some uncertainty exists in the human studies.

The students at Gulfside Elementary School were probably exposed to increased levels of particulate matter (PM) while Stauffer was operating. However, the lack of good information regarding their PM exposures does not allow ATSDR to determine with any certainty if these exposures constituted a hazard. No quality air monitoring data or reliable estimates from computer modeling are available for the school. Because this information is lacking, it was not possible to accurately estimate exposure to particulate matter for children who attended the school. Therefore, it was not possible to determine if particulate matter in air was a hazard to students at the Gulfside school.

It should be noted that the risk of adverse health effects from long-term exposure to sulfur dioxide and particulate matter existed while the students and adults were being exposed. There is uncertainty in estimating health risks for former Gulfside students because the human studies measured sulfur dioxide and particulate matter in the same year that mortality was measured; whereas, exposures at Gulfside Elementary School stopped over 20 years ago. Because of the relatively low levels of exposure from 1978 to 1981, it is unlikely that former students and adults who were exposed in the past are currently at risk of harmful effects. Therefore, ATSDR concludes that a scientific study of Gulfside former students is not appropriate at this time.

ATSDR, in collaboration with the University of South Florida, initiated and recently completed a project to determine whether the former Gulfside Elementary students could be located. The preliminary results of the project indicate that 557 (91%) of 615 former students were located.

This information could be useful for future dissemination of health information and health education to former students.

iv. Former Stauffer Workers

ATSDR reviewed and evaluated available worker exposure data for the Stauffer site, which operated from 1948 through 1981. The data available for evaluating occupational exposures are limited and cover only the last 10 years that the facility was in operation (1972–1981). No occupational exposure data were available for the first 25 years the facility was in operation. Based on review and evaluation of the available data, ATSDR has reached the following conclusions:

- ▶ **Former workers at Stauffer were intermittently exposed to asbestos or asbestos-containing materials at levels that indicate an increased theoretical risk of cancer, but it is unlikely (based on air monitoring data) that workers are at risk of asbestosis.**
- ▶ **Former workers at Stauffer were intermittently exposed to arsenic, nickel, and chromium at levels that indicate an increased theoretical risk of cancer.**
- ▶ **Former workers at Stauffer were intermittently exposed to carbon monoxide, chromium, hydrogen sulfide, lead, nickel, phosphorus compounds, sulfur dioxide, as well as total dust, quartz, and silica at levels that can cause adverse health effects.**
- ▶ **Because of known and suspected past exposures for former workers, ATSDR will hold a workshop in Atlanta, Georgia, for scientific discussion and input for planning health/medical screening for Stauffer former workers. ATSDR will seek input from medical and scientific experts for the identification and risks of appropriate screening tests. ATSDR believes the screening service will provide valuable information to the former worker, his/her physician, and family.**

v. Health Statistics Review

At ATSDR's request, FDOH conducted a cancer incidence analysis of populations living near Stauffer. ATSDR made the request on behalf of concerned citizens who perceived there to be an excess of cancer and other illnesses among citizens who live or lived near the Stauffer facility. The cancers analyzed included bone, brain, leukemia, lung and bronchus, lymphomas, melanoma, mesothelioma, and thyroid cancers.

For the combined years of 1990–1999, SIRs for all cancers examined were less than or equal to what would be expected for the target area. However, when examining the time periods of 1990–1994 and 1995–1999 separately, mesothelioma in women was significantly elevated during 1990–1994 (3 cases observed, 0.6 cases expected; SIR=5.0; $p<0.02$).

ATSDR obtained information from the death certificates of the 3 women diagnosed with mesothelioma, and cross-referenced names with the Stauffer former worker list to identify a possible exposure relationship. There was no apparent relationship with the Stauffer site for these female cases (and for a spouse with the same last name). In addition, cause of death information for deceased former workers did not indicate an elevated number of deaths due lung diseases consistent with Stauffer site contaminants, e.g., asbestosis.

3. Future Exposures

On-site slag would pose a public health hazard if the site was developed into a residential neighborhood. Radium-226 is the principal radiologic contaminant of concern. The primary concern is that gamma radiation from the slag would result in significantly elevated radiation doses if the land was developed for residential use.

If the Stauffer facility was developed into a residential neighborhood, arsenic levels in the pond soils area would be a public health hazard. Long-term exposure over many decades could increase the risk of cancer from accidental soil ingestion from hand-to-mouth activity.

E. Recommendations

ATSDR is making the following recommendations for the Stauffer site:

- ▶ Prevent exposure to radiation in the on-site slag should the site be considered for residential development.
- ▶ Conduct follow-up activities for users of residential and commercial wells that contained elevated levels of arsenic and lead to determine whether the wells are still in use and to ensure that the users are aware of the potential risks from past use of the wells.
- ▶ Review new site data, as they become available, for potential public health implications, including the results of the recent geophysical and hydrogeologic site investigations.
- ▶ Provide health education to former Stauffer workers focused on healthy habits for respiratory illness care and prevention through (1) local meetings; (2) established repositories, and/or (3) mailing using available mailing lists of former workers.
- ▶ Provide health education to local health care providers including health information related to (1) taking patients' environmental exposure histories and (2) available contaminant-specific case studies and fact sheets.
- ▶ Continue to provide health education to area residents and people who attended Gulfside Elementary from 1978 to 1981 through distribution of (1)

Neighbor-2-Neighbor community newsletters for the Stauffer site, (2) chemical-specific and exposure-related fact sheets, and (3) public health fact sheets.

- ▶ Provide health education materials in Greek if necessary based on the needs of the Tarpon Springs community.
- ▶ Conduct a special workshop of medical experts for the discussion, input, and guidance for possible future health activities (e.g., focused health/medical screening) for former Stauffer workers.
- ▶ For public health surveillance and health information purposes, continue to monitor the area for the annual incidence of mesothelioma and lung cancer.

F. Public Health Action Plan

The public health action plan (PHAP) for the Stauffer site contains a description of actions that have been or will be taken by ATSDR and other government agencies at the site. The purpose of the PHAP is to ensure that this public health assessment not only identifies public health hazards associated with the site, but also provides a plan of action to prevent or minimize the potential for adverse human health effects from exposure to site-related hazardous substances.

1. Division of Health Assessment and Consultation Activities

- ▶ ATSDR's Division of Health Assessment and Consultation, in conjunction with the Pinellas County Health Department, will conduct follow-up activities for users of residential and commercial wells that contained elevated levels of arsenic and lead. ATSDR will determine whether the wells are still in use and to ensure that the users are aware of the potential risks from past use of the wells.
- ▶ ATSDR's Division of Health Assessment and Consultation will review new site data as they become available, including the results of the recent geophysical and hydrogeologic site investigations, and modify this public health assessment if necessary.

2. Division of Health Education and Promotion Activities

- ▶ ATSDR's Division of Health Education and Promotion will provide health education to former Stauffer workers focused on healthy habits for respiratory illness care and prevention through (1) local meetings; (2) established repositories, and/or (3) mailing using available mailing lists of former workers.
- ▶ ATSDR's Division of Health Education and Promotion will provide health education to local health care providers including health information related to (1) taking patients' environmental exposure histories and (2) available contaminant-specific case studies and fact sheets. This information will be provided by mail and at local meetings, including grand rounds and/or other professional medical meetings.

- ▶ ATSDR's Division of Health Education and Promotion will continue to provide health education to area residents and people who attended Gulfside Elementary from 1978 to 1981 through distribution of (1) Neighbor-2-Neighbor community newsletters for the Stauffer site, (2) chemical-specific and exposure-related fact sheets, and (3) public health fact sheets. These materials will be provided during local meetings, through established repositories, and/or by mail (upon request).
- ▶ ATSDR's Division of Health Education and Promotion will consider providing health education materials in Greek upon request.

3. Division of Health Studies Activities

- ▶ ATSDR Division of Health Studies will coordinate and facilitate the planning and conduct of a one-day workshop in Atlanta, GA, for the purpose of identifying appropriate follow-up health activities or screening for former Stauffer workers. Approximately 4 to 5 "environmental medicine" experts will be identified and invited to attend. ATSDR also plans to invite a former worker, who lives in the community, to attend this session and provide information about working conditions and work-related exposures, especially exposures that occurred between 1947 and 1970. A community representative and an area physician will also be invited. The workshop will be conducted according to a meeting agenda and suggested guidelines in order to optimize input by experts. ATSDR will provide a summary of the workshop to interested stakeholders. The workshop is tentatively planned for May 2003.
- ▶ ATSDR's Division of Health Studies will work with FDOH to monitor the annual incidence of mesothelioma and lung cancer in the site area. This monitoring activity will be conducted for public health surveillance reasons and will not necessarily be focused on a particular site or group of sites. FDOH has agreed to provide an annual data report to ATSDR for addressing this surveillance activity recommendation. ATSDR will be responsible for communicating findings of annual surveillance to the community. This reporting will be a component of ATSDR's broader health communications activities with the Stauffer community.

1. PURPOSE AND STATEMENT OF ISSUES

ATSDR has been involved with the Stauffer Chemical Company (Stauffer) site since the early 1990s, both to respond to community health concerns and to fulfill the agency's congressional mandate of conducting public health assessments for all sites on the Environmental Protection Agency's (EPA's) National Priorities List (NPL). During the 1990s, ATSDR released a preliminary public health assessment and several health consultations that evaluated levels of environmental contamination at and near the former Stauffer facility. In early 2000, several Tarpon Springs residents contacted the ATSDR Ombudsman regarding the possible health impacts of previous operations at the Stauffer site. In January 2001, the ombudsman released his report (ATSDR 2000a) regarding the Stauffer site. The ombudsman's report contained a number of recommendations, including that ATSDR prepare a new public health assessment for the Stauffer site. This public health assessment document was prepared in response to the Ombudsman's recommendation and the concerns of the Tarpon Springs community.

This public health assessment presents a comprehensive review of available environmental sampling data and other site information regarding the levels of contamination at and near the Stauffer site and their potential impact on the surrounding community. In developing this public health assessment, ATSDR collected and compiled a large volume of data and information in order to evaluate whether people were exposed in the past, or are currently being exposed, to contaminants from the Stauffer site at levels that could be harmful to their health. This includes some data and information that were not considered in ATSDR's previous site evaluations such as (1) Stauffer air emissions data, meteorological data, and ambient air monitoring data; (2) recent private well sampling data; (3) personal air sampling data and occupational exposure information for former Stauffer workers, and (4) updated State of Florida cancer registry statistics. Moreover, in this document, ATSDR addresses issues of particular concern to a number of area residents, specifically, the potential impact of Stauffer's past air emissions on the health of the surrounding community, including former Gulfside Elementary students, and the potential impact of occupational exposures on the health of persons who worked at Stauffer.

2. BACKGROUND

ATSDR is a federal agency within the U.S. Department of Health and Human Services. The agency is authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) to conduct public health assessments at hazardous waste sites.

2.1. Site Description and History

The Stauffer site is ½-mile south of the Pasco-Pinellas county line and 1.6 miles east of the Gulf of Mexico. The Anclote River borders the site to the west and southwest. Commercial and residential property borders the remainder of the site and a large residential area is across the river from the site. Land use in the area is mixed, including industrial, commercial, recreational, and residential. The Gulfside Elementary School is directly north of the site, across Anclote Boulevard.

The main plant site, as shown in Figure 1, Appendix A, is south and west of Anclote Road. This area originally included the phosphate ore processing and phosphorus production facilities, waste disposal facilities, office and administration buildings, and several railroad spurs used for receiving raw materials and shipping products. The area to the north, between Anclote Road and Anclote Boulevard, contained production wells for process water and was also used for crushing and storing slag and other waste materials. The railroad lines, many of the buildings, and much of the waste slag were removed after the plant closed. A site manager and a few security guards are now the only site occupants. The entire site, including the northern and southern portions, is surrounded by a chain-link fence, and access to the site is controlled 24 hours a day.

From 1947 to 1981, the 138-acre site operated as a chemical plant that extracted elemental phosphorus from phosphate ore. The facility included a phosphate ore processing area, elemental phosphorus production facilities, a slag processing area, and a system of settling ponds. Residual wastes from the operation were disposed in on-site settling ponds and in the slag processing area, both of which are groundwater contamination sources. Wastes included calcium carbonate, calcium sulfite/sulfate, calcium fluorosilicate, calcium fluoride, calcium hydroxide, phosphate rock, phosphate nodule dust, sand, clay, "phossy" water, slag fines, and other particulates. In addition, a number of pollutants were emitted from the facility into the air including particulate matter, phosphorus pentoxide, sulfur dioxide, fluorides, carbon monoxide, heavy metals, and radionuclides. The Victor Chemical Company opened the operation. Stauffer Chemical Company¹ took over the plant in 1960 and operated it until it shut down in 1981. In 1986, activities associated with permanently decommissioning and dismantling the facility began, including a number of investigations to evaluate the nature and extent of environmental contamination. Most of the production facilities were demolished in 1991 and 1992 (Weston 1993; Parsons 2002).

¹Stauffer Management Company (SMC) was formed in 1987 as a result of a divestiture of the Stauffer Chemical Company.

Waste products were disposed of on the property. It is estimated that 500,000 tons of waste were disposed of on-site between 1950 and 1979 (NUS 1989). On-site waste was disposed of in many ways. Scrubber water was emptied into waste lagoons. The lagoons were 4–8 feet above mean sea level, approximately 40 feet from the river's edge. The waste scrubber liquid discharging into the lagoons was made up primarily of hydrofluoric, phosphoric, fluorosilic, silic, and sulfuric acids. The waste scrubber discharge into the lagoons is well documented, but it is suspected that phossy water might also have been discharged. Phossy water can have a phosphoric content of up to 1,700 parts per million (ppm). The waste deposited at the bottom of the waste lagoons was periodically dredged and deposited in piles as large as 35 feet high on the side of the lagoons. In addition, furnace dust was disposed of into an isolated pond. There was potential for slag overflow, which might have contained phosphorus pentoxide, arsenic, uranium, phosphate, and elemental phosphorus. Other waste was disposed of by burial or fire. In 1985, it was estimated that 32,400 cubic yards of precipitated material had been removed from the first two waste lagoons (NUS 1991). Before 1978, about nine hundred 55-gallon drums of calcined phosphate sand were reportedly buried on-site near the southernmost slag piles.

In May 1994, the site was added to EPA's NPL. NPL includes those hazardous waste sites that require clean-up action under the Superfund law (CERCLA).

2.2. Site Visit

ATSDR staff visited the site in June 2001 with representatives from SMC. During the site visit, ATSDR observed that the main plant site and the slag processing area were surrounded by chain-link fences topped with barbed wire and posted with warning signs. A guard was present to provide additional security for the site. ATSDR staff observed that the former waste disposal ponds were filled with vegetation and the pond soil piles were also overgrown. ATSDR also observed that the ground in this area contains residual crushed slag and is sparsely vegetated. The railroad spur lines and many of the buildings had been removed from the site. Only the administrative office, guard house, and a few other structures remained. The remainder of the site was well grassed.

The former slag processing area north of Anclothe Road was also fenced. The central part of this area contained little vegetation and was covered with crushed slag.

ATSDR staff also took a boat tour to observe the portion of the site next to the Anclothe River. It was observed that the river bank was made of slag; erosion of the slag into the river was evident.

ATSDR staff revisited the site in April 2002. At that time, vegetation was being cleared from the site in preparation for the site-wide geophysical study. ATSDR staff observed that much of the vegetation had been already been cleared and more buildings and structures had been removed from the site since the June 2001 site visit.

2.3. Demographics, Land Use, and Natural Resource Use

To identify and define the size, characteristics, location, and possible unique vulnerabilities of populations near the Stauffer site, ATSDR studied available demographics and land use information. Demographics information helps ATSDR understand the number and makeup of the population. Land use information helps identify possible exposure situations in the area (that is, what activities are occurring, have occurred, or might occur in the future). This study helps determine whether and how people might come in contact with site-related contamination, as well as the characteristics of those people.

2.3.1. Demographics

2000 census data show that the city of Holiday, approximately 1.5 miles northeast of the site, has a population of 21,904 and that Tarpon Springs, 2 miles southeast of the site, is home to 21,003 people (US Census Bureau 2000). Of the people living in these two communities, approximately 5% are children under 5 and 28% are over 65 years of age. Approximately 13% (1,676) of housing units in Holiday and 8% (908) of housing units in Tarpon Springs are categorized as “seasonal, recreational, or occasional use” (US Census Bureau 2000). The local Chamber of Commerce estimates that 750,000 tourists visit the area each year.

According to 2000 census data, approximately 9,200 people live within a 1-mile radius of the site (see Figure 2, Appendix A).

2.3.2. Land Use

Land use near the Stauffer site is mixed, including industrial, commercial, recreational, and residential. The Anclote River is a well-used river system. Activities ranging from agriculture, industry, recreation, and fishing all take place on and near the river.

Subdivided residential areas exist in the vicinity of the site, in both Holiday and Tarpon Springs. Business along the Anclote River within 1 mile of the site include a power-generating plant (Florida Power Anclote Plant), an auto salvage yard, and a boat repair facility and marina. Many of these businesses release small amounts of air contaminants while the Anclote Plant is a very large emissions source of several pollutants, including sulfur dioxide and particulate matter. East of US Route 19, most land is rural with improved pasture, rangeland, agriculture (including citrus and row crops), and tree farming. Most of the remainder of the watershed is vacant or environmentally sensitive areas (tidal and freshwater marshes, flood plain, isolated hardwood swamps, pine flatwoods).

Multiple schools, day care facilities, health care facilities, nursing homes, and day care centers are within 2 miles of the site. Gulfside Elementary School is directly north of the site; the school opened in January 1978, approximately 4 years before the Stauffer facility shut down (November 1981). Tarpon Springs Middle School and St. Nicholas Parochial School are within 1 mile southwest and south of the site, across the river. In addition, Sunset Hills Elementary School and

Tarpon Springs High School are just over 1 mile south of the site. A nursing home, a rehabilitation center, and multiple assisted living facilities are across the river from the site within the 1-mile boundary. More than 20 other health care facilities, day care centers, and schools are between 1 and 2 miles away from the site, in and around the cities of Tarpon Springs to the south and southeast and Holiday to the northeast of the site.

In addition, several recreational areas are in the general vicinity of the site, including a golf course directly across the river, and several parks and beaches.

2.3.3. Natural Resource Use

2.3.3.1. Groundwater

2.3.3.1.1. Hydrogeology

The hydrogeology of the site area has been well studied. Water levels (including tidal fluctuations), groundwater flow direction, the direction and magnitude of vertical hydraulic gradients, horizontal gradient, flow velocity, and groundwater-surface water interactions were evaluated as part of ongoing site investigations. Some question remains, however, about the site hydrogeology and the full impact that site-related groundwater contamination could have on nearby water supplies. Data collected to date led SMC and its contractors to conclude that groundwater flows toward the Anclote River and that contaminants detected in the shallow aquifer migrate in that direction only and are not migrating to the deeper aquifer. An independent review initiated by EPA of data collected to date challenges certain interpretations (Black and Veatch 2000). In response, SMC is conducting additional study of groundwater flow direction and the connectivity between the shallow and deep aquifers. This section presents an overview of the current understanding of local hydrogeologic conditions.

The region of northwestern Pinellas and southwestern Pasco counties in which the Stauffer site is located is underlain by sand, clay, and limestone. Local hydrogeology is characterized by three hydrostratigraphic units: a surficial aquifer, a semi-confining unit, and the Floridan Aquifer. Water is reached at an average depth of 8 feet below land surface (bls) (NUS 1989; Weston 1993; Parsons 2002).

The *surficial aquifer* consists primarily of permeable sands (fine- to medium-grained quartz and shelly sand, with sandy clay at the bottom of the aquifer) and ranges in thickness between approximately 2 and 30 feet on-site. Remedial investigation (RI) findings show that the hydraulic conductivity of the deposits has varied (23–344 feet/day), with an average rate of 220 feet/day (Weston 1993). Seaburn and Robertson (1987), however, reported hydraulic conductivity estimates ranging from 0.62–2 feet/day in the surficial aquifer. Black and Veatch's (2000) reinterpretation of earlier pumping test results indicate a hydraulic conductivity of 267.9 feet/day in the surficial aquifer, but they conclude overall that hydraulic conductivity measurements taken to date are inadequate for the site.

Despite the many site-related hydrogeologic investigations, some information gaps exist. Per the work plan for the upcoming groundwater studies (Parsons 2002), two activities will be performed to help fill data gaps identified by EPA and others.³

- *Extending existing on-site monitoring well network.* Additional wells will be installed in 12 locations in both the surficial and Floridan Aquifers. This will include six “well nests” to characterize the extent of flow between the two aquifers. The new and existing well network will be used to further evaluate the hydrogeologic flow scheme (rate and direction of flow) and to further characterize groundwater quality conditions. [Note: No monitoring of the deeper aquifer has occurred since the 1993 RI. Further, the extent of contamination in the deeper aquifer is not sufficiently delineated with the existing monitoring well network.]
- *Conducting a tidal study.* Data will be collected to further study the influence of tides on both aquifers.

The primary objective of the studies as stated in the work plan, however, is to evaluate the impact of groundwater characteristics on the proposed groundwater source control remedy. The studies will focus on the pond and process areas of the site. Field work began in July 2002 and study findings are expected to be available in Spring 2003.

It is unclear whether changes in area water use might have any significant impact on future groundwater flow conditions in the site area. Black and Veatch (2000) report that increasing population size throughout the Tampa Bay area has resulted in an increase in water demand. They warn that this increasing demand could potentially affect groundwater in the Tarpon Springs area (i.e., by producing a cone of depression within the Floridan Aquifer). This points to the need to continue to study site hydrogeologic conditions and to be aware of possible changes that could occur over time.

2.3.3.1.2. Usage (Water Supply Wells)

No known potable wells (containing water suitable for drinking) are currently in use on site or immediately down gradient (south/southwest) of the site (Weston 1993). Some groundwater near the site (cross-gradient areas east and west of the site and on the opposite side of the Anclote River) is used for potable water, lawn irrigation, and commercial and industrial purposes. The surficial aquifer in the area is used primarily for agriculture and irrigation purposes and is not generally used as a drinking water source. Water from the Floridan Aquifer is used for domestic, industrial, and agricultural purposes (Weston 1993). Most private and public potable wells near the site draw water from the deeper Floridan Aquifer (NUS 1989). Well-depth information is

³SMC responded and amended its work plan to address comments received from the EPA, Florida Department of Environmental Protection (FDEP), U.S. Geological Survey, School Board of Pasco County, Pi-Pa-TAG, Inc., Pinellas County Health Department, and Black and Veatch, Inc., all of whom commented on the draft sampling plan and expressed concerns about the completeness of existing data sets.

A thin *semi-confining unit*, ranging in thickness from 1 to 8 feet, exists between the surficial and Floridan Aquifers (Weston 1993; Parsons 2002). The unit consists of clay and silty clay, with some limestone fragments. The RI concluded that this layer restricts the vertical movement of water from the surficial aquifer to the Floridan Aquifer system below. The RI also concluded that the vertical hydraulic gradient is low, suggesting that the predominant movement across the site is horizontal, not vertical (Weston 1993). Black and Veatch (2000) confirmed the low hydraulic conductivity of the clay layer (1.22 feet/day), but indicate that the extent of hydraulic “communication” between the surficial and underlying materials has not been determined throughout the site. In addition, the authors concluded that (1) the extent and integrity of the semi-confining layer needs to be further defined, including any potential breaching of this layer by sinkholes²; and (2) more sampling and comparison of contamination between shallow and deep well clusters are needed to support conclusions about whether contaminants in the shallow aquifer are migrating to the upper portion of the Floridan Aquifer.

The *Floridan Aquifer* consists primarily of limestone. The upper portion of the Floridan Aquifer, referred to as the upper Floridan, Tampa Formation, or Tampa Limestone, has a thickness ranging from 60 to 150 feet in the vicinity of the Stauffer site, starting at 17–37 feet bls in the study area. This aquifer is one of the primary water-bearing formations in the Tarpon Springs area. The hydraulic conductivity estimates in the Floridan Aquifer reportedly range from 1.9 to 19.1 feet/day (Seaburn and Robertson 1987; NUS 1989; Weston 1993; Parsons 2002).

Studies conducted to date show that groundwater flow direction in both aquifers appears to be south to southwest, with discharge from both aquifers to the Anclote River. This is based on the interpretation of water level readings—groundwater elevations are higher in the aquifers than the river. A hydraulic connection exists between the aquifers and the river, as demonstrated by a direct relationship measured between tidal fluctuations in the river and the daily water levels in the aquifers (Seaburn and Robertson 1989; Weston 1993; Flow 2001). Because of the tidal influence, conditions in the aquifer are considered “dynamic” with short-term fluctuations in flow rate and directions (Seaburn and Robertson 1987; Black and Veatch 2000). An analysis accounting for this fluctuation still indicated that net groundwater flow direction in both aquifers in the vicinity of the site is southwest toward the Anclote River. Both aquifers rise and fall in a similar manner in response to the tidal cycle and precipitation events. According to Weston (1993), these responses are directly related to changes in surface elevations of the Anclote River and not to any breaching of the confining unit (Weston 1993). Water level data indicated a slight downward gradient between the surficial and Floridan Aquifers (Seaburn and Robertson 1987). The potentiometric contour lines generated during the RI led to the conclusion that no groundwater movement from the Stauffer site is occurring beneath and across the Anclote River (Weston 1993).

²The possible impact of sink holes has been a major concern voiced by community members (ATSDR 2000a).

documented only for five area residential and commercial potable wells. These well depths range from 35 to 70 feet bls—all in the Floridan Aquifer (FDOH 2002).

Conflicting documentation exists about the number of private wells in the site vicinity. ATSDR's 1999 health consultation indicated that approximately 230 private wells were located within 1 mile of the site boundary (ATSDR 1999a). Although public water is available, "some" private wells are used in a small residential area west of the site. In addition, approximately 20 homes in the Hickory Lane and Cemetery Lane area within the Holiday Utilities service area use private wells. The nearest residential potable well is 2,500 feet northwest (up gradient) of the site. During the RI, a well inventory was conducted in a 3-mile radius around the site from the Southwest Florida Water Management District's (SFWMD's) database of all public and private water wells in southwest Florida: 84 public and private water wells were identified within a 3-mile radius and 31 wells (all privately owned) were within a 1-mile radius (Weston 1993). A more recent review of well permits issued by SFWMD between 1970 and 2000 indicates that 10 private domestic wells are within a 1-mile radius of the site and 23 private domestic wells are within 3 miles of the site (SMC 2001). Although the exact number of private wells in the site area is unknown, most of the wells close to the site – those that could potentially be impacted by site groundwater contaminants – have been identified. The locations of these and other known water supply wells (both private and public) within approximately 1 mile of the site are shown in Figure 3, Appendix A.

Because of community concern regarding the use of private water supplies in the vicinity of the site, ATSDR carefully reviewed groundwater quality data available for nearby wells—including wells located up-gradient, cross-gradient, and on the opposite side of the river from the site (see Section 3.2.2).

Six public utilities have well fields within a 4-mile radius of the site: the closest are Holiday Utilities (2,000 feet up-gradient) and Pasco County Utilities (3,000 feet up-gradient). The other utilities (City of Tarpon Springs, Aloha Utilities, Forest Hills, and Crestridge Gardens Utility Corporation) are 10,000–13,000 feet from the site. All wells are in the Floridan Aquifer and all are greater than 39 feet in depth. These wells have not been affected by Stauffer groundwater contamination.

Historic use of on-site groundwater is not well documented, but it is known that groundwater was used for both potable and industrial purposes at the Stauffer plant. Drinking water was drawn primarily from wells within the deeper Floridan Aquifer before Stauffer's connection to the public water supply. Weston (1989) reports that at one time the site had 17 wells for potable water use, along with some others of lower quality that were used for facility purposes. Only four of these seventeen wells were regularly used. Other wells were abandoned over the years, mostly because of elevated chloride levels.

2.3.3.2. Surface Water

The major surface water in the site area is the Anclote River. The primary use of the Anclote River is recreation, including boating and swimming, and support of wildlife.

Because of its large sea-grass beds, the river is an ideal habitat and breeding ground for clam and scallop beds, some of which are harvested by local residents. One harvesting area is reportedly less than ½ mile from the Stauffer waste lagoon area (NUS 1989).

Recreational fishing has historically been reported as a local pastime, and a popular fishing spot is less than 1 mile down gradient of the Stauffer site at the Florida Power's Anclote Plant's cooling canal (NUS 1989). The Florida Department of Health (FDOH) issued a health advisory suggesting that adults limit their consumption of largemouth bass, bowfin, and gar from the Anclote River to one meal per week (FDOH no date). The advisory, which is based on mercury contamination in fish, is not related to the Stauffer site. FDOH also suggested that children and pregnant and nursing women consume only one meal of these fish per month.

A marina is approximately ¾ mile upstream of the site, and a golf course is across the river (Weston 1993). A number of beaches are on the river near the site. Pasco County Beach, on the north shore 3,500 feet west of the Stauffer site in Anclote River State Park, is the closest. Three beaches in the Gulf of Mexico are within 2 miles of the site (Sunset Beach, Howard Park, and Anclote Gulf Park). Activities at the numerous parks and beaches in the area include boating, fishing, picnicking, swimming, and using the playgrounds.

The land surrounding the river has many uses as well. East of US Route 19, most of the land is rural with improved pasture; rangeland; and agriculture including citrus, row crops, and tree farming. Most of the remainder of the watershed is vacant; many areas are considered environmentally sensitive areas (tidal and freshwater marshes, flood plain isolated hardwood swamps, pine flatwoods). In addition, an urbanized area parallels US Route 19, consisting of subdivided residential areas, commercial property, and both light and heavy industrial activities, including ship repair, electric power generating, and auto salvage yards along the river (NUS 1989).

Because the river is brackish near the Stauffer site, it is not used as a source of drinking water (NUS 1989). However, the Tampa Bay Water district is currently reviewing plans and proposing sites for a seawater desalination plant in the area.⁴ Negotiations are underway between the project team and Florida Power to co-locate the new desalination plant with the existing Anclote Plant (approximately ¾ miles downstream of the Stauffer site) (Tampa Bay Water 2002; H. Knight, Public Information Project Coordinator for Tampa Bay Water's Gulf Coast Desalination Project, personal communication).

⁴Tampa Bay Water is a special district created by interlocal agreement among member governments—Hillsborough County, Pasco County, Pinellas County, St. Petersburg, New Port Richey, and Tampa. Tampa Bay Water provides wholesale water to member utilities, who in turn provide water to nearly 2 million people in the tricity area (www.tampabaywater.org/WEB/Htm/About-Us/overview.htm).

3. ENVIRONMENTAL CONTAMINATION AND OTHER HAZARDS

In this section, ATSDR reviews the environmental data collected at the Stauffer site and selects contaminants warranting further evaluation. ATSDR evaluated the adequacy of the sampling conducted, identified the maximum concentration and frequency of detection of the contaminants found in various media, and compared the maximum detected concentrations with health-based screening values or comparison values (CVs).

ATSDR selected contaminants at this site based on the following specific factors:

- ▶ An understanding of contaminant concentrations detected on-site and off-site.
- ▶ A determination of overall data quality (field data quality, laboratory data quality, and sample design).
- ▶ A comparison of on-site and off-site contaminant concentrations with appropriate CVs.
- ▶ Community health concerns.

The health-based CVs used in this report are concentrations of contaminants that the current public health literature suggest are “safe” or “harmless”. These comparison values are quite conservative because they include ample safety factors that account for most sensitive populations. ATSDR typically uses comparison values as follows: If a contaminant is never found at levels greater than its comparison value, ATSDR concludes the levels of corresponding contamination are “safe” or “harmless.” If, however, a contaminant is found at levels greater than its comparison value, ATSDR designates the pollutant as a contaminant of concern and examines potential human exposures in greater detail. Because comparison values are based on extremely conservative assumptions, the presence of a contaminant at concentrations greater than comparison values does not necessarily suggest that exposure to the contaminant will result in adverse health effects. More information on the comparison values used in this report can be found in Appendix D.

Identification of contaminants of concern narrows the focus of the health assessment to those contaminants most important to public health. When a contaminant of concern in one medium is selected, that contaminant is also reported in all other media. In subsequent sections, ATSDR evaluates whether exposure to these contaminants has public health significance.

In this document, contaminants found **on-site** will be discussed separately from contaminants found **off-site**. Environmental sampling data for contaminants in soil, groundwater, surface water, and sediment, both on-site and off-site, are summarized in Tables 1-25 of Appendix B and discussed briefly in sections 3.1 and 3.2 below. A more detailed discussion of site sampling investigations and environmental sampling data for these media is provided in Appendix C. Environmental sampling data related to airborne contaminants (i.e., air emissions and ambient air monitoring data) are discussed in section 3.3.

3.1 On-site Contamination

3.1.1. Soil

ATSDR gathered surface and subsurface soil data from reports generated by parties involved in site investigations and monitoring, beginning in 1988. Data from the on-site soil sampling studies indicated that the concentrations of six contaminants consistently exceeded the applicable ATSDR CVs: antimony, arsenic, cadmium, thallium, fluoride, and radium-226. Asbestos was found in only two on-site surface soil samples.

This section summarizes surface and subsurface soil data collected at and near the Stauffer site, broken out in the following subsections.

- *Former pond soils.* Surface and subsurface soils from former ponds, dredged pond material, and an on-site drainage ditch.
- *Slag material.* Surface soils from slag pits and slag storage area, as well as slag-containing material from an on-site roadway.
- *Other on-site soils.* Surface and subsurface soils from the main production area, southeast property, northeast property, and unused portions of the site.
- *On-site asbestos sampling.* Surface and subsurface soils from all areas of the site.

Figure 4 in Appendix A shows the layout of the Stauffer site and soil sample locations. Appendix C provides a detailed account of the site soil sampling investigations and their findings.

3.1.1.1 Former Pond Soils, Dredged Materials, and Drainage Ditch

Process wastes generated by the Stauffer plant were disposed of in seventeen on-site settling ponds and lagoons. Process wastes included scrubber liquor (containing amounts of hydrofluoric, phosphoric, fluorosilic, and sulfuric acids) and precipitated material (containing amounts of calcium sulfate/sulfite, calcium silicate, calcium fluoride, phosphate sand, and calcined phosphate dust). The ponds might have also received discharges of “phossy water,” although clear documentation of this practice is lacking. Phossy water was used to provide protective contact to the phosphorus product. In addition, some of the ponds received overflow from a concrete-lined calcium silicate slag pit. Other potential slag components are phosphorus pentoxide, arsenic, uranium, phosphate, and elemental phosphorus (NUS 1989). All of the former pond areas are now dry. Over the years, large quantities of the precipitated material from several of the ponds were dredged and transferred into piles adjacent to the ponds (NUS 1989). This waste was designated as nonhazardous under the Resource Conservation and Recovery Act (RCRA) (NUS 1991).

All but one of the former ponds and the dredged materials were sampled for metals, other inorganics, and radionuclides. Pond 50 was covered over by growth at the time of sampling in

December 1989 and was no longer visible (Weston 1990a). Three of the former ponds and a sample from the former dredging area were also analyzed for VOCs, semivolatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs). Samples included surface soils, subsurface soils, and composite samples taken from multiple depths. Table 2 in Appendix B summarizes the findings of these pond and dredged material soil studies.

Sampling of the surface and subsurface soils in the areas of the former ponds and from dredged pond materials indicates that these areas generally contain the highest levels of contaminants on-site. Several of the ATSDR CVs were exceeded in these soil samples, many of which included surface soils. Contaminants that exceeded their respective CVs follow: several SVOCs, arachlor-1248, antimony, arsenic, cadmium, chromium, lead, thallium, and fluoride. Radium-226 was the only radionuclide analyzed in the pond soils, and it exceeded the CV in nearly all samples. Maximum concentrations of radium-226 were detected in pond 39 and its dredged material (i.e., pile 1) in the northeast property; pond 42 in the western portion of the main production area; and ponds 44A, 45, 48, 49A, 49C, 49D, and 51 and their dredged material (i.e., pile 2) in the southern portion of the main production area.

ATSDR conducted a more detailed analysis of those substances most frequently detected at levels above CVs (arsenic, cadmium, and thallium) in pond soils and dredged soils. This analysis included a review of the spatial distribution of these metals as well as an assessment of the overall representativeness of the maximum detected concentrations. ATSDR calculated mean and median concentrations for these three metals, grouping pond samples and associated dredge samples based on their general location on site—that is, north ponds (ponds 39 and 52), the west pond (pond 42), and the south ponds (all other ponds).

Contaminant concentrations were generally consistent across the site. Mean concentrations of arsenic in these areas ranged from approximately 113 to 133 ppm, with the maximum reported concentration of 340 ppm in pond 42. The mean cadmium concentration ranged from 32 to 40 ppm, with a reported maximum of 66 ppm in pond 39. Mean concentrations for thallium ranged from 12 to 23 ppm. The maximum concentration of thallium (37 ppm) was found in dredge materials from deeper depths of the southern ponds, although thallium was consistently detected in surface samples as well. Median concentrations for these contaminants are similar to the mean concentrations, which suggests that the concentration ranges were evenly distributed and not overly weighted toward the low or high end of the ranges.

Three samples also were obtained from soils in a drainage ditch running along the northwestern border of the property. All levels of contaminants in the drainage ditch soils were below their respective CVs. These samples also showed lower concentrations of contaminants when compared with the pond or dredged material soils, as well as the other on-site surface soils.

3.1.1.2 Slag and Slag-Containing Material

Calcium silicate slag was generated during the processing of phosphate ore at the Stauffer site. Periodically, this slag was tapped from an upper layer of the molten product and discharged to a

concrete-lined slag pit. The slag was then sprayed with quenching water, crushed, and transported to a slag processing area north of the main production area (NUS 1989).

The crushed slag was used as a construction material at several locations both on-site and off-site. For example, it was used as fill in a portion of Meyers Cove, in the construction of roads on-site and off-site, in residential driveways, and in concrete used in the foundation of several community buildings. Off-site locations believed to have received slag-containing materials include schools, residences, and commercial properties.

Several studies examined the slag material remaining on-site, as well as the soil beneath the slag pile. One study also examined on-site road materials that were constructed from the slag. Table 3 in Appendix B summarizes the findings of the on-site slag studies. This table excludes data obtained from the slag-containing road materials.

Sampling of the surface soils found in the areas where slag material was processed (i.e., the slag pits in the main production area and the storage area north of the main production area) generally indicated that these areas contained the lowest concentrations of contaminants found on-site. A few contaminants (aluminum, manganese, and radium-226), however, were found at their highest concentrations in these areas. In addition, three contaminants exceeded their respective ATSDR CVs: benzo[a]pyrene (only one sample was analyzed for SVOCs, arsenic (exceeded CV in one sample), and radium-226 (in all 12 samples). Only one sample was analyzed for volatile organic compounds (VOCs). None of the VOCs analyzed for in this sample were detected.

Roadway materials collected along the western border of the site from 1–4 foot depths were analyzed for metals, cyanide, fluoride, total phosphorus, and radionuclides (Weston 1993). Detected level of site-related substances were generally comparable to those detected in on-site slag samples, though some metals and gross beta radiation were detected at slightly higher levels in roadway materials as compared to on-site slag (see Appendix C).

3.1.1.3 Other On-Site Soils

Sampling data for on-site *surface* and *subsurface* soils also are available from past site investigations for several locations around the site. Sampling of the surface soils found in the other areas of the site (excluding the ponds, dredged material piles, and slag processing areas discussed previously) revealed the following contaminants at the maximum concentration on-site: several VOCs; SVOCs; dieldrin; p,p-DDT; cobalt; iron; nickel; sodium; vanadium; and gross alpha and beta radiation. Several other contaminants were found at the same order of magnitude as the maximum concentrations found in the pond areas. Table 4 in Appendix B presents a summary of the on-site surface soil data, and Table 5 in Appendix B summarizes mean and median concentrations for five contaminants of potential concern. These five contaminants were those detected most frequently at levels above ATSDR CVs and/or by the greatest margin (e.g., arsenic, cadmium, and thallium), as well as those associated with site operations (e.g., fluoride, total phosphorus) in the on-site surface soils.

Sampling of the subsurface soils on-site generally showed lower concentrations of contaminants when compared with the on-site surface soils. A few samples, however, show higher concentrations of some contaminants than the maximum concentration found in surface soils. These contaminants are toluene, arsenic, cadmium, magnesium, mercury, thallium, and fluoride. The samples with the highest concentrations of contaminants in the subsurface soils were obtained mainly from the northeast property and along the western portion of the main production area. Five contaminants (antimony, arsenic, cadmium, thallium, and fluoride) exceeded their respective CVs in the subsurface soils.

3.1.1.4 Asbestos

In April 1998, Parsons conducted a comprehensive site-wide study of the presence of asbestos in on-site soils (Parsons 1998). This sampling was performed as a follow-up to the September 1997 sampling. One hundred forty-seven areas (surface and subsurface) of the site were analyzed for asbestos. These areas included all portions of the site, including the slag storage area and the ponds. This analysis found only one “asbestos positive” sample. The sample was obtained from surface soils of the parking lot, near the main office in the main production area, and contained 0.25% chrysotile asbestos (Parsons 1998).

An additional 66 surface and subsurface soils were collected based on historical asbestos uses or storage. Only one of these surface soil samples contained asbestos. The sample, which contained 0.75% chrysotile asbestos, was collected just south of the maintenance building within the main production area (Parsons 1998).

3.1.2. Groundwater

ATSDR gathered groundwater monitoring data from reports generated by parties involved in site investigations and routine monitoring, beginning in 1985. Appendix C provides a detailed list of the site groundwater sampling programs. In general, the objective of each of these programs was to measure the nature and extent of site groundwater contamination, including the potential for off-site migration. Because several sampling events were conducted by different investigators, the designation of the sampling locations has changed over the years. Table 6 in Appendix B describes the well designations used in the various studies. The data summary tables and Figure 5 (monitoring well locations) in Appendix A use the well designations from the RI. A detailed list of the site groundwater sampling investigations is provided in Appendix C.

3.1.2.1. Monitoring Wells⁵

Table 7 (surficial aquifer) and Table 8 (Floridan Aquifer) in Appendix B summarize groundwater sampling data from on-site monitoring wells and two monitoring wells (MW-11S and MW-04F)

⁵ All of the Stauffer monitoring wells are on-site except for MW-11S and MW-04F, which are across the Anclote River. The sampling data for these two wells are evaluated with the on-site monitoring well data and are included in the on-site monitoring well data summary tables.

southwest of the site on the other side of the Anclote River. Monitoring wells are not used for drinking water but are used to characterize groundwater quality and possible movement from the site. As described previously, no potable water supplies exist on-site; therefore, no one is ingesting or otherwise coming in contact with groundwater beneath the site. Tables 7 and 8 present the range of contaminant concentrations detected in each aquifer during the various sampling rounds. Unless otherwise noted, the number of samples represent a unique sampling event that includes multiple samples from individual monitoring wells. Tables 7 and 8 also compare the maximum detected concentrations to CVs, as a means of identifying contaminants of potential concern or interest.

- ▶ *Shallow aquifer.* The contaminants most frequently exceeding ATSDR CVs (in more than 40%–50% of the samples) were arsenic, fluoride, and radon-222. Other contaminants exceeding ATSDR CVs in one or more samples were aluminum, antimony, boron, cadmium, chromium, iron, lead, lithium, manganese, mercury, nickel, selenium, thallium, vanadium, sulfate, trichloroethylene, gross alpha, and radium-226.
- ▶ *Floridan Aquifer.* Few detected concentrations of contaminants exceeded ATSDR CVs in tested wells in the Floridan Aquifer. Site-related contaminant concentrations were generally lower in the Floridan Aquifer compared with the surficial aquifer, although similar concentrations of arsenic and fluoride were reported in nested wells MW-9S and MW-3F, which are on the river shore down gradient of the main production area.

3.1.2.2. Plant Water Supply Wells

As previously discussed, 17 wells were used for potable water at one time or another at the Stauffer plant, along with some other wells of lower quality that were used for facility purposes. Wells 5, 12, 13, and 15 were reportedly the primary sources of potable water for the facility; all were 1,500–2,500 feet to the northeast (away from the river) from most of the other numbered wells. These wells were used for drinking water until February 1979, when Stauffer began distributing bottled drinking water. In late 1979 or early 1980, the facility completed its tie-in to the City of Tarpon Springs' water supply, and used potable city water until it ceased operations in 1981 (Kelly 2002).

Some of the plant's on-site wells were abandoned over the years, mostly because of elevated chloride levels. Others (including wells 7, 10, and 14) were used as backup wells or for process water or irrigation. Well 14, in the main plant area, was used for emergency standby. Wells 7 and 10 were 4-inch wells used for supplementary water and were "of poorer quality." Well 7 was used very little in the years leading up to 1974. Neither well 7 nor well 10 was in use for potable water in 1976. As of 1977, well 10 was restricted to lawn sprinkling for several years; well 14 had been locked since January 14, 1977 because of high chloride levels. Well 12 was also part of the backup potable water system. Well 17 was drilled for the Turbulaire (kiln cooler) scrubber. The office and silo wells were used for irrigation only. The track hopper (slag pit) and roaster wells were used for process water only, and were not considered potable. The kiln-scrubber well was

used for scrubber make-up water. ATSDR was unable to identify any documents that explain the use for the “plant tank” mentioned in several laboratory reports.

Available on-site well sampling data are contained in lab reports from the years 1948–1982 (except for the period 1960–1965). These reports include data for the plant’s potable wells as well as the process and irrigation wells. However, ATSDR is evaluating only the sampling data associated with the potable wells. Victor Chemical Works (1948–1960) and SMC (1965–1982) tested on-site wells for a number of analytes, including aluminum, ammonia, bicarbonate, calcium, carbon dioxide (free), carbonate, chloride, dissolved solids from conductance, fluoride, hardness, hydrogen sulfide, hydroxide, iodine demand (Na_2SO_3), iron, magnesium, nitrate, organic (ether extraction), pH, phosphate, phosphorus, silica, soap hardness (CaCO_3), sodium, sulfate, suspended solids, and total solids. Not all analytes were analyzed in every sample, however. Bacteriologic analyses were also routinely conducted. For the purposes of this evaluation, ATSDR focused on fluoride, phosphorus, sulfate, and iron in potable water wells 5, 12, 13, and 15, and backup potable water wells 7, 10, and 14.⁶

Table 9 in Appendix B lists maximum levels of these four contaminants in the potable water wells. Table 10 in Appendix B shows the maximum levels of these four contaminants in the backup potable water wells.

3.2. Off-Site Contamination

For the purposes of this evaluation, off-site is defined as the area outside the property boundary of the Stauffer plant and slag storage area (Figure 1, Appendix A).

3.2.1. Soil and Slag-Containing Materials

Sampling data for off-site soils and road and building materials are available from several studies. These data include surface soil samples from Gulfside Elementary School and other off-site locations and samples of slag-containing materials in roadways, driveways, and foundations in the surrounding community. All of the areas are accessible to the public; they include public roads, private residences, a recreation complex, a government building, and commercial facilities. It should be noted that not all of the samples obtained for each study were analyzed for the same contaminants.

Off-site sampling studies revealed that surface soils and building materials sampled in the surrounding community contained lower concentrations than were found on site. Only arsenic and radium-226 consistently exceeded ATSDR CVs off-site, but were generally detected below

⁶ATSDR also reviewed the reported contaminant concentrations in the plant’s water tank, noting that the reported levels fell below maximum reported concentrations shown in Table 9, Appendix B. The contaminant levels in the backup wells (shown in Table 10, Appendix B) were higher than, or comparable to, the levels shown in Table 9.

naturally occurring background levels. None of the off-site sampling studies found conclusive evidence of asbestos.

3.2.1.1. Gulfside Elementary School

Gulfside Elementary School opened in January 1978. The school is approximately 600 feet from the former slag storage area, directly across Anclothe Road, north of the Stauffer site (NUS 1991). Several studies have focused on characterizing the soils and building materials on the school property.

The samples obtained from the surface soils surrounding the Gulfside Elementary School were analyzed for metals, other inorganics, and radionuclides. No VOCs, SVOCs, pesticides, or PCBs were analyzed in any of the samples obtained from the school. Table 11 in Appendix B presents a summary of the surface soils analyzed from the Gulfside Elementary School.

Sampling results indicate that the surface soils on the school property contained lower concentrations of virtually all of the contaminants found at the Stauffer site. The only two contaminants detected above ATSDR's CVs were arsenic and radium-226, though these substances were detected below available "background" levels. More specifically, arsenic, which only slightly exceeded its CV (0.5 ppm) in one sample (0.6 ppm), was also detected at levels at or below reported background arsenic levels. Arsenic concentrations identified in background samples collected during site investigations in wooded areas on the site itself ranged up to 0.91 ppm; geometric average arsenic concentrations in Florida soils have been reported to be 0.42 ppm with an arithmetic average of 1.34 ppm (Chen 1999). Maximum detected radium-226 values in the school soils slightly exceeded the state-wide average; it is unclear to what extent, if any, the site contributed to the measured amounts of radium-226 in school soils. The remaining metals, other inorganics, and radionuclides were detected at concentrations below their respective CVs. The 20 surface soil samples that were analyzed for asbestos showed no amount of asbestos present.

Sampling of the road materials around the school property, as well as the soil beneath the roads and roofing material on the school, all showed concentrations of radium-226 that exceeded the CV. The soil beneath the road also showed concentrations of radon-222 that exceeded concentrations found in the on-site surface soils. All of these building materials contained far lower concentrations of the contaminants found in the on-site slag.

3.2.1.2. Other Off-Site Locations

Several other locations in the community surrounding the Stauffer site were examined, mostly in response to residents' concerns that slag material from the Stauffer site was used in the construction of their homes, driveways, and roadways. Most of the studies only examined external gamma radiation (EGR) levels from these materials; however, a few studies did perform additional analyses of the slag materials. Community exposure to gamma radiation was the subject of a recent ATSDR health consultation (ATSDR 2002).

Only arsenic and radium-226 exceeded the ATSDR CVs in any of the off-site samples. Several other contaminants, although detected at concentrations below their respective CVs, exceeded the maximum on-site slag concentrations. These contaminants were aluminum, antimony, barium, cobalt, copper, mercury, selenium, silver, thallium, and vanadium. The maximum concentrations were generally found in the roadbed or pavement, or both, used to construct Bluff Boulevard and Gulfview Road, as well as in a few residential building slabs and driveways. It is reasonable to expect that other constituents used in the building material formulation might have contributed toward the elevated concentrations in these samples.

In July 1998, core samples obtained from a residential basement, a roadway, and the Stauffer slag storage area were microscopically analyzed to determine whether the off-site building materials were constructed with the slag material from the site. Although the off-site samples were “visually indistinguishable” from the Stauffer slag sample, this did not prove that the slag materials originated at the Stauffer site. This study concluded that slag material from the site was distributed for use as aggregate in roads, road beds, and some building materials. The study also found that a second elemental phosphorus plant, in Nichols, Florida, also distributed slag for these uses (considered a safe practice at the time). No conclusions could be made about the extent to which the Stauffer site slag material is contained in the surrounding community roads and buildings (EPA 1999a).

3.2.2. Groundwater

3.2.2.1. Private Wells

Thirty-eight private wells (residential potable, commercial potable, and irrigation wells) near the site have been sampled since 1988. The Pinellas County Department of Health did most of the sampling in 1990, 1997, and 1999–2001 as part of Florida’s SuperAct Underground Storage Tank Program and at the specific request of area residents. Table 12 in Appendix B lists the wells sampled and the frequency of sampling. Figure 6 in Appendix A shows the locations of each of these wells.

It should be reemphasized that residential and commercial wells are believed to draw water from the Floridan Aquifer. In addition, many of these wells are considered hydrogeologically upgradient of the site. Irrigation wells, some located just west of the site, draw water from the surficial aquifer, but are not used for drinking water purposes. The exact number of residential, commercial, and irrigation wells in the site area and the number currently in use are unknown.

Table 13 (residential potable wells), Table 14 (commercial potable wells), and Table 15 (irrigation wells) in Appendix B present the range of detected concentrations for selected chemical and radiologic parameters in the private wells sampled near the Stauffer site. The tables include only (a) those substances detected at concentrations exceeding ATSDR CVs or (b) substances for which no CV is available.

Arsenic, chromium, lead, nickel, thallium, zinc, chlorides, sulfate, gross alpha radiation, and radium-226 were all detected at concentrations above ATSDR CVs, but at relatively low frequencies. Most were also detected at concentrations no more than 10 times higher than CVs. Among these contaminants, arsenic and lead were detected the most frequently at levels above ATSDR CVs and the levels tended to exceed the CVs by the greatest magnitude. Note that fluoride (a known contaminant beneath the Stauffer site) was detected in only 3 of the 30 potable wells—at concentrations well below the ATSDR CV (less than 270 ppb). Further, detected fluoride concentrations were generally comparable or below those detected in “background” wells located in the northeast quadrant of the site (MW 1S and 1F, MW-7ES, and MW-98-1).

3.2.3. Surface Water and Sediment (Anclote River)

This section summarizes surface water and sediment sampling data collected at or near the Stauffer site. Because the Anclote River flows immediately adjacent to the Stauffer site, the river has been the focus of various site-related studies. Data from these studies were collected and summarized to support ATSDR’s health effects evaluation for the surface water and sediment exposure pathways. Separate, detailed data summaries for surface water and sediment are presented in Appendix C of this document.

For the purposes of ATSDR’s evaluation, the sampling areas within the Anclote River were broken into four distinct regions to enable a better assessment of possible impacts of the site on the surrounding surface water and sediments. Sampling locations were classified as

- ▶ upstream (samples from areas upriver of the easternmost site boundary),
- ▶ adjacent (samples collected in the Anclote River between both property lines of the Stauffer site, but not including Meyers Cove),
- ▶ Meyers Cove (limited exclusively to those samples collected in the cove)⁷, and
- ▶ downstream (any sample collected northwest, or downriver, of Meyers Cove).

Locations were grouped to enable a critical assessment of site impact on river quality and to characterize conditions at various exposure points along the stretch of the Anclote River near the site.

Tables 16–23 in Appendix B summarize available surface water and sediment data. The tables list the contaminants detected in each region of the Anclote River and the range of concentrations measured for each contaminant throughout the 15 years of sampling. The tables indicate where and when the highest concentrations were measured and how frequently each contaminant was detected. Because the surface water and sediments were evaluated to characterize human exposure and assess the possibility of adverse effects due to exposure, the tables also list a health-based CV.

⁷Meyers Cove was evaluated separately for four reasons. First, the cove is slightly downstream of the site but near it. Second, it is protected from wind and current, with the potential to “trap” contaminants. Third, part of it was filled to build an access road during plant operation. Fourth, community members have expressed specific concern about site impact on Meyers Cove.

ATSDR used drinking water and soil CVs for screening detected surface water and sediment concentrations. Because the Anclote River is not used as a drinking water source, use of drinking water CVs to evaluate incidental exposures associated with swimming or other recreational exposure scenarios is a conservative screening approach. Similarly, soil CVs are not directly applicable when evaluating sediment exposures in that soil CVs are developed based on the assumptions that quantifiable amounts of soil and associated dust can be incidentally ingested on a daily basis. Sediments, on the other hand, tend to have greater water content, are often submerged, and are relatively inaccessible, likely making contaminants less directly bioavailable. As such, use of soil CVs is also a conservative approach to evaluating sediment data.⁸

Following are summary statements supported by the findings of the sampling studies reviewed in this section. The results of individual sampling studies are discussed in greater depth under the Surface Water Data and Sediment Data sections in Appendix C.

- *Surface water (Anclote River) conditions.* As part of three site-related studies, surface water has been sampled at and near the site between 1987 and the present. (Table 24, Appendix B, presents the surface water sampling location designations; Figure 7, Appendix A, shows sampling locations.) Most samples were analyzed for metals, phosphorus, fluoride, and radiologic activity. The most extensive sampling for radiologic parameters has been part of an SMC monitoring program in the immediate vicinity of the site. Contaminants detected at concentrations above drinking water CVs at least once during this time frame include antimony, arsenic, boron, chromium, iron, lead, thallium, vanadium, fluoride, sulfate, gross alpha and beta radiation, and radium-226. Contaminants detected and for which no CVs are available include calcium, magnesium, sodium, phosphorus, and polonium-210.

A review of available sampling data from Meyers Cove and areas upstream of, adjacent to, and downstream of the site provides limited insights on temporal and spatial variations of contamination in the different reaches of the river. Generally, the quality of the surface water has remained relatively constant. For some metals and fluoride, however, decreasing concentrations were observed over time in samples collected by SMC (1987 to present) in the immediate vicinity of the site. Spatially, trends (if any) depend on the particular substance detected. Arsenic, boron, and sulfates were consistently detected at concentrations above CVs throughout the river. Although gross alpha and beta radiation are similar both upstream and in Meyers Cove, radium-226, radon, and polonium-210 are at least three times higher in Meyers Cove than in areas immediately upstream. However, no meaningful spatial analysis for radioactivity is really possible. None of the samples collected in far upstream and downstream samples were tested for a full suite of radiologic parameters to enable a comparative analysis.

⁸The CVs used in this analysis only consider direct contact with surface water and sediment. These screening values do not take into account possible effects associated with indirect exposures (e.g., contaminant uptake in fish or shellfish).

- **Sediment conditions.** Four studies evaluated the quality of sediment in the Anclote River between 1988 and 1993. (Table 25, Appendix B, presents the sediment sampling location designations; Figure 8, Appendix A, shows sampling locations.) Sediment samples were generally analyzed for multiple metals, fluoride, phosphorus, and radiologic activity. Arsenic, thallium, fluoride, radium-226, polonium-210 were the only substances detected at least once at concentrations above CVs. The highest concentrations were generally detected in Meyers Cove and during 1988 and 1989 sampling events.

Contaminant-specific spatial trends can be summarized as follows: Detected concentrations of metals, although generally below CVs, were elevated above background near the site, particularly in Meyers Cove. The highest concentrations of aluminum, arsenic, barium, chromium, silver, and vanadium were detected at Meyers Cove. Arsenic, however, was the only substance consistently detected in concentrations above its CV. Levels of phosphorus and total organic carbon (TOC) are also highest at Meyers Cove and areas adjacent to the site (just upstream of Meyers Cove) compared with upstream and downstream locations. Likewise, gross alpha and beta radiation were measured at the highest levels in Meyers Cove and adjacent to the site (up to 50 times higher activity than in upstream samples). Radium-226 and polonium-210 were only detected in Meyers Cove and adjacent to the site, but detected concentrations just slightly exceeded CVs.

Less obvious trends were observed with thallium and fluoride. Thallium was detected in only one sample collected downstream in 1988. Fluoride had one detection above its CV upstream of the site, adjacent to the site, and in Meyers Cove, with the highest concentration detected upstream. All three of these were part of the same study and were laboratory estimated quantities (NUS 1989). With those three exceptions, however, fluoride concentrations are generally higher in Meyers Cove than elsewhere in the river, though below its CV.

Because sediment data are only available for a 5-year period, it is difficult to assess temporal trends in sediment quality. Differences in detected concentrations in this relatively small data set are likely a result of sampling and analysis differences instead of a function of changes over time. For instance, NUS (1989) detected considerably higher fluoride levels throughout the river than were measured in later studies. Although at face value this could indicate an overall decrease in fluoride in Anclote River sediments, it is more likely a sampling artifact.

3.2.4. Biota (Fish and Shellfish)

During development of this public health assessment, ATSDR consulted FDEP, FDOH, the Florida Fish and Wildlife Conservation Commission (FFWC), and the Florida Marine Research Institute to identify available fish tissue and shellfish sampling data and to learn about fish surveys and counts in the local area. However, no fish or shellfish sampling data were identified for the

site area. Further, information related to specific fish consumption patterns for the site area are not available; only county/regional statistics have been compiled according to local officials.

3.3. Air Contamination

This section of the public health assessment evaluates the nature and extent of contaminants released to the atmosphere from the Stauffer facility. Residents of Tarpon Springs and other communities surrounding the Stauffer facility expressed concerns about the impact of the Stauffer air emissions and asked ATSDR to evaluate whether exposure to these contaminants might have resulted in adverse health effects, especially for persons who lived near the Stauffer facility and for persons who attended Gulfside Elementary School while the Stauffer facility was in operation.

3.3.1. What Were the Air Emissions Sources From Stauffer's Processes?

The Stauffer facility produced elemental phosphorus from phosphate rock ore mined elsewhere in Florida. The processing began by feeding the ore, which typically contained between 10% and 13% phosphorus, through a rotary kiln that heated and fused the ore into lumps called nodules. The kiln was fired by combustion of both carbon monoxide (generated elsewhere at the facility) and residual fuel oil. The phosphate rock nodules were then crushed and cooled.

The processed nodules, along with feeds of coke and silica, were then melted in an electric arc furnace. After each batch of material processed, operators “tapped” the furnace by pouring out molten liquids. These liquids included slag (calcium silicate) and ferrophosphorus (an iron-rich material). Once poured from the furnace, these liquids cooled and solidified. The resulting solid waste was stored on-site and ultimately sold for further reuse. Gaseous outputs from the furnace contained elemental phosphorus, carbon monoxide, and trace contaminants. Most of the gases were captured for further processing. Some waste gases were vented to a venturi scrubber before being emitted to the air. However, all waste gases formed during furnace tapping were not captured by the air pollution control equipment; uncollected gases (such as phosphorus pentoxide, sulfur dioxide, and fluorides) vented directly to the environment. The amount of these fugitive emissions was never characterized at Stauffer.

Most of the gases generated by the furnace were vented to a condenser, which separated the liquid phosphorus product from carbon monoxide gas and an emulsion waste. The phosphorus product was stored in underwater tanks and eventually loaded into tank cars for shipping to various processing plants. The carbon monoxide gas was routed to the rotary kiln for use as fuel. A “rotary roaster” retrieved phosphorus from the emulsion waste, which was composed of phosphorus, water, and dust. The roaster was fired by the fuel oil combustion.

3.3.2. Emissions Data: What Contaminants Were Released to the Air?

This subsection reviews the information available on air emissions from the Stauffer facility, focusing on what chemicals were emitted and in what quantities. The extent of emissions data available for any facility often depends on regulatory requirements. At the time Stauffer operated,

local, state, and federal environmental regulations focused primarily on a small number of contaminants and air pollution sources. Consequently, the emissions data available for Stauffer are not comprehensive in terms of the pollutants and sources considered. Many parties investigated Stauffer's air emissions, but the majority of emissions data reported for the site were generated by periodic stack tests Stauffer conducted in fulfillment of air permit requirements. The emissions data are most complete from 1972 to 1981, presumably because environmental regulations did not require emissions characterization in earlier years.

Following are summary statements about the emissions data.

- *Pollutants for which emissions data are available.* Emissions data for Stauffer are available for four pollutants: fluorides, particulate matter (size fraction not specified), phosphorus pentoxide, and sulfur dioxide. These emissions data are based almost entirely on stack tests that Stauffer conducted to comply with air permit requirements, which focused exclusively on emissions from point sources (or stacks). As a result, emissions data for fugitive releases are not available. Although emissions data from other phosphorus production facilities provide insight on past emissions from Stauffer, the usefulness of data from other facilities is limited because of differences in raw material composition, production levels, process configurations, operating parameters, and efficiencies of air pollution control devices.
- *Fluoride emissions.* Stauffer measured fluoride emissions in multiple stack tests from several processes. The best estimate of annual fluoride emissions is 6.06 tons per year, based on stack test results and annual emissions statements submitted by Stauffer to state regulators. This estimate likely understates actual fluoride emissions, because it does not account for fugitive emissions from potentially important unit operations, such as furnace tapping. The extent to which emissions are understated is not known.
- *Particulate matter emissions.* The available site documents include results from numerous stack tests that measured particulate matter emissions from several of Stauffer's permitted operations. These stack tests suggest that Stauffer released 242 tons of particulate matter per year, but the particle size distribution of these releases was never quantified. The total particulate matter release estimate (242 tons/year) is based only on emissions measured from stacks at seven unit operations. Although the major point sources were identified and characterized, none of the site documents include estimates of particulate matter emissions from fugitive sources, such as wind-blown dust, materials handling operations, and fumes not captured by the furnace hood. Therefore, even if the stack test results were accurate, the best available estimate of particulate matter emissions understates the actual emission rates by an unknown, and perhaps considerable, amount.
- *Sulfur dioxide emissions.* Stauffer and environmental regulators extensively studied the facility's sulfur dioxide emissions, presumably because northern Pinellas County was designated as a nonattainment area for sulfur dioxide. The results of numerous stack

tests suggest that Stauffer emitted 1,545 tons of sulfur dioxide to the air per year (based on data compiled for the years before the facility's boilers began burning low-sulfur-content fuels). Because sulfur dioxide is not expected to have been released in large quantities from the fugitive sources at Stauffer, this estimate is believed to be a reliable account of actual sulfur dioxide emissions. The majority (93%) of the sulfur dioxide emissions were from the rotary kiln.

- *Phosphorus pentoxide emissions.* Unlike fluorides, sulfur dioxide, and particulate matter, all of which were measured in numerous stack tests at Stauffer, phosphorus pentoxide emissions were measured in a single round of stack tests conducted in 1972. This round of stack tests focused on emissions from two sources expected to release the greatest amount of phosphorus pentoxide and suggest that facility-wide phosphorus pentoxide emissions were 11.6 tons per year. Because results from this single test might not be representative of typical operating conditions at Stauffer, confidence in the phosphorus pentoxide emissions data is low.
- *Temporal variations in air emissions.* The site documents provide no information on how emissions from Stauffer's sources changed from hour to hour or during specific processing conditions, such as after process start-up and shut-down. Although the stack test results are suitable for making reasonable estimates of annual average emission rates for some pollutants, they do not characterize temporal variations in emissions, which might be considerable for some sources.
- *Data quality.* Limited information is available on the methods and quality control procedures associated with Stauffer's stack testing, and on the facility operating conditions during most stack tests. This lack of information raises questions about the quality of emission rates. However, stack tests performed for fluoride, particulate matter, and sulfur dioxide emissions were all conducted according to the specifications of Stauffer's air permits and typically reviewed by local and state regulators. Moreover, rigorous stack testing methods were available in the 1970s for particulate matter and sulfur dioxide, and the most recent site documents imply that EPA methods were followed for certain measurements (e.g., particulate measurements were made using EPA method 5). These latter observations give greater confidence that the stack test results, particularly for sulfur dioxide and particulate matter, are reasonably representative of Stauffer's stack air emissions.
- *Other contaminants.* The Stauffer facility undoubtedly released other contaminants into the air, including metals, radionuclides, and various inorganic phosphorus compounds. However, the available site documents do not present any emissions data, measured or estimated, for these other pollutants.

3.3.3. Meteorologic Data and Air Quality Modeling Analysis: Where Did the Air Emissions Go?

This section reviews meteorologic data and presents an air quality modeling analysis to characterize how Stauffer's emissions affected air quality in the Tarpon Springs area. Several parties studied the local meteorologic conditions, including the Pinellas County Department of Environmental Management (PCDEM), Stauffer, two local airports, and Florida Power, but the majority of information available is from PCDEM and the National Climatic Data Center (NCDC). This summary focuses on two periods of interest: the years when elemental phosphorus production occurred at Stauffer (up to 1981), and the years after these production activities ceased (since 1981).

Following are brief summary statements emphasizing the most notable features of the meteorologic data and air quality modeling analysis:

- ▶ The most extensive meteorological data available were collected at three locations: PCDEM's Anclote Road monitoring station, the St. Petersburg-Clearwater International Airport, and the Tampa International Airport. All three meteorologic stations operated for a common period spanning 18 years (1979 to 1996). During this time, the prevailing wind direction observed at all three stations was roughly from the northeast to the southwest. This trend suggests that long-term pollutant impacts from Stauffer would likely be greatest southwest of the facility. The prevailing wind direction notwithstanding, winds also periodically blew from all other compass directions during certain times of the year. Therefore, Stauffer's emissions likely had short-term air quality impacts in all compass directions around the site, with the extent of these impacts determined by how often a location was downwind from the facility. The least prevalent wind direction at all three stations was roughly from the south to the north, which is the direction that would blow Stauffer's emissions toward the Gulfside Elementary School.
- ▶ Sulfur dioxide concentrations coupled with wind direction provide compelling evidence that Stauffer's emissions accounted for a very large portion of the sulfur dioxide levels measured at PCDEM's Anclote Road monitoring station. Specifically, on hours when winds blew from Stauffer toward the monitoring station, sulfur dioxide levels, on average, were more than five times higher than those when winds blew from other directions. This trend was observed only during years when Stauffer's production processes operated, thus strengthening the argument that Stauffer's emissions accounted for the elevated levels.
- ▶ Concentrations of total suspended particulates (TSP) coupled with wind direction suggest that many sources in the area, including Stauffer, contributed to the measured levels of air contamination. In general, TSP concentrations on days when winds blew from the Stauffer facility toward the Anclote Road monitoring station were consistently higher than those observed on days when winds blew in other directions. However,

substantial TSP levels were measured on days when winds did not blow from Stauffer's operations toward the monitor, indicating that other sources in the area undoubtedly contributed to the measured TSP concentrations as well. Other factors not evaluated, such as precipitation and wind speed, also likely affected the measured TSP concentrations.

3.3.3.1. Meteorologic Data

ATSDR identified five potential sources of hourly meteorologic data that might be representative of the Tarpon Springs area. Raw data from two of these sources were not available. For the other three stations, ATSDR obtained the entire histories of meteorologic data, some dating back to 1948. Table 26 in Appendix B presents key features of these stations; the corresponding meteorologic data from those stations are presented here. The summaries focus on two distinct time frames. First, prevailing wind directions are presented for the years 1979 to 1996—the longest time frame over which all three stations were operating. Second, prevailing wind directions are presented for all observations collected between 8:00 AM and 3:00 PM between January 1978 and May 1981. This time frame represents the hours that children were most likely at Gulfside Elementary School at the same time that Stauffer's main production processes were still operating. Daytime hours during summer months are included in this second time frame.

- *Data set 1: PCDEM's Anclote Road Station.* From January 1979 to September 1996, PCDEM collected continuous observations of meteorologic conditions at its Anclote Road monitoring station immediately southeast of the former Stauffer facility. The station logged hourly observations of wind speed and wind direction. Over the entire period of record, the station's completeness ratio was 89.1%, meaning that valid observations for wind speed and wind direction were recorded for 89.1% of the total number of hours in this time frame. This completeness ratio varied from year to year. In the first 3 years this station operated (1979–1981), the completeness ratio was only 77%; for the last 6 years (1991–1996), the ratio was nearly 99%. This difference suggests that PCDEM's meteorologic station might have experienced operational difficulties during its first years of collecting data, but these difficulties were apparently resolved. For reference, EPA guidance suggests that hourly observations of meteorologic data should be at least 90% complete for use in regulatory dispersion modeling analyses (EPA 2000).

Figures 9 and 10 in Appendix A present wind roses for PCDEM's Anclote Road meteorologic station. The wind rose in Figure 9 presents the statistical distribution of wind speed and wind direction for the entire period of record for this meteorologic station. The wind rose indicates that winds most frequently blew roughly from northeast to southwest. In fact, wind directions between 15° and 75° accounted for 24% of the hourly observations recorded at this meteorologic station. Although winds predominantly blew from the northeast, winds blowing in all directions at varying speeds were observed throughout the period of record. The least prevalent wind direction was from the south to the north (the wind direction that would most likely

blow emissions from Stauffer to the Gulfside Elementary School). Specifically, wind directions between 180° and 210° accounted for only 4% of the hourly observations.

Figure 10 illustrates the distribution of wind speed and wind direction observed between January 1979 and May 1981 during the hours of 8:00 AM–3:00 PM. This time frame is when children were most likely to be at the Gulfside Elementary School. The prevailing wind pattern during this time frame (from the west-northwest) was considerably different than the prevailing wind pattern for the entire period of record. However, the wind rose for the daytime hours again indicates that winds did not frequently blow from south to north.

The average wind speed measured at the Anclote Road monitoring station was 5.1 miles per hour. This average wind speed is lower than those observed at the Tampa and St. Petersburg-Clearwater International Airports. The reason for this inconsistency is not known.

- *Data set 2: Tampa International Airport.* NCDC provided the entire history of meteorologic data collected at the Tampa International Airport, from 1948 to the present. The Tampa International Airport is approximately 20 miles southeast of the former Stauffer facility, and no significant terrain features are located between the airport and the former facility. In addition to recording hourly observations of wind speed and wind direction, this station logged measurements of temperature, precipitation, barometric pressure, relative humidity, cloud cover, and several other parameters. Between 1979 and 1996, this station recorded valid measurements of wind speed and wind direction for 99.7% of the hours, suggesting that the station rarely experienced operational difficulties.

As the wind rose in Figure 11, Appendix A shows, the prevailing winds observed at the Tampa International Airport were also roughly from northeast to southwest, although this station had more of a east-northeasterly component compared with the prevailing winds at the Anclote Road station. At the Tampa International Airport, wind directions between 15° and 75° accounted for 23% of the valid hourly observations recorded at this station. Although a prevailing wind direction is apparent from Figure 11, winds blew from other compass directions at other times of the year. Consistent with trends observed at the Anclote Road station, winds from south to north—the direction that would blow emissions from Stauffer toward the Gulfside Elementary School—accounted for the lowest fraction of hours at the Tampa International Airport. Specifically, wind directions between 180° and 210° occurred only 7% of the time.

Figure 12 in Appendix A shows how winds varied during the time that children were most likely present at Gulfside Elementary School while Stauffer operated (i.e., between January 1978 and May 1981, during the hours of 8:00 AM and 3:00 PM). A single prevailing wind pattern for this subset of hours is less apparent, although winds

blowing from west to east and from east to west account for most of the recorded observations.

The average wind speed reported for the Tampa International Airport over its entire period of record is 8.3 miles per hour. It is not known why this average wind speed is 63% higher than the average wind speed for the Anclote Road monitoring station.

- *Data set 3: St. Petersburg-Clearwater International Airport.* NCDC also provided the entire history of meteorologic observations recorded at the St. Petersburg-Clearwater International Airport. The meteorologic station at this airport, which is approximately 18 miles south of the former Stauffer facility, has collected hourly observations of numerous meteorologic parameters since 1973. Between 1979 and 1996, this station obtained valid observations for wind speed and wind direction in 97.3% of the possible hours.

The wind rose for the St. Petersburg-Clearwater International Airport (Figure 13, Appendix A) is similar to those for the two other stations. Most notably, the prevailing wind pattern at this station is also from roughly the northeast to the southwest, and wind directions between 15° and 75° accounted for 22% of the total observations. Similarly, the wind directions that would blow Stauffer's emissions toward Gulfside Elementary School (between 180° and 210°) were relatively infrequent, accounting for only 8% of the total hourly observations. Figure 14 in Appendix A illustrates the wind patterns at St. Petersburg-Clearwater International Airport during the hours when children would most likely be at the Gulfside Elementary School. No clear patterns are apparent from this wind rose.

Between 1979 and 1996, the average wind speed at the St. Petersburg-Clearwater International Airport was 9.1 miles per hour, which is reasonably consistent with the average wind speed observed at the Tampa International Airport (8.3 miles per hour).

- *Data set 4: Stauffer's on-site meteorologic stations.* Recent site summaries indicate that Stauffer previously operated as many as three "wind speed and directional instruments" (Kelly 2002). Although some of the site documents report meteorologic conditions measured by these devices over short time frames, a complete set of raw data from these stations is apparently not available. According to a recent communication, SMC does "... not have a single, comprehensive set of continuous, on-site meteorologic data" (Kelly 2002). Moreover, no information is readily available on the quality of Stauffer's observations. Based on the lack of measured data and supporting documentation, ATSDR recommends basing all conclusions and inferences regarding meteorology on the data available from the airport and Anclote Road stations.
- *Data set 5: Florida Power's Anclote Plant.* When reviewing site documents and discussing Stauffer operations with local and state regulators, ATSDR learned that Florida Power operated at least one continuous meteorologic station either at or near its

Anclote power plant in southern Pasco County. Meteorologic data for these stations were not readily available from any of the parties ATSDR contacted, including representatives from Florida Power .

3.3.3.2. Wind Direction Analysis of Ambient Air Monitoring Data

Simultaneous measurements of wind direction and ambient air concentrations (EPA 2002a) allow for detailed analyses of the sources that most likely contribute to air pollution. PCDEM measured ambient air concentrations of sulfur dioxide and TSP at the same time it measured wind direction. ATSDR examined trends among these parameters for two time frames: 1979–1981 and 1982–1984. The first time frame was selected because it is the longest period of record for which simultaneous meteorologic and air quality measurements are available during the time that Stauffer's production processes were operating. The second time frame was selected to have an equal period of record (i.e., 3 years) after Stauffer's production processes shut down. The following paragraphs review comparisons of air quality measurements to concurrent wind direction observations:

- *Sulfur dioxide.* Between 1979 and 1981, PCDEM recorded valid measurements for both wind direction and sulfur dioxide concentration on 21,848 hours (EPA 2002a). Figure 15 in Appendix A illustrates how the sulfur dioxide concentrations, on average, varied with wind direction during this time frame. Sulfur dioxide levels at the Anclote Road monitoring station were highest when winds blew from directions between 300° and 360° (or 0°). These wind directions would have blown emissions from various locations on the former Stauffer facility toward the monitoring station. Of particular note, a wind direction of 315°—the direction which resulted in the highest average sulfur dioxide concentration—would have blown emissions from Stauffer's rotary kiln stack toward the monitoring station.

Although Figure 15 provides compelling evidence that Stauffer's emissions accounted for the elevated levels of sulfur dioxide measured near the facility, it does not rule out the possibility that emissions from Florida Power's Anclote Plant might also have contributed to the air pollution levels, because wind directions between 300° and 360° (or 0°) would also blow emissions from this facility to the monitoring station. Figure 16 in Appendix A, however, strongly suggests that emissions from Florida Power had minimal impacts on the sulfur dioxide levels at the Anclote Road monitoring station. Specifically, Figure 16 illustrates how sulfur dioxide concentrations varied with wind direction in the 3 years immediately after Stauffer's shutdown of major processing operations. Elevated sulfur dioxide concentrations between 300° and 360° (or 0°) are absent from this figure. The most logical explanation for the differences between Figures 15 and 16 is that Stauffer's emissions accounted for a large fraction of the elevated sulfur dioxide levels at the Anclote Road monitoring station.

- *TSP.* Examining associations between TSP concentrations and wind direction is not as straightforward as the analysis in the previous section, because the TSP and wind direction measurements were collected over different averaging periods. TSP

concentrations are 24-hour average measurements, whereas wind directions are 1-hour averages. The impact of wind direction on particulate matter levels was assessed by evaluating how TSP concentrations, on average, vary with the number of hours per day that the Ancloste Road monitoring station was downwind from the Stauffer facility.

Between 1979 and 1981, PCDEM collected valid 24-hour average TSP concentrations at the Ancloste Road monitoring station on 170 days (EPA 2002a). On 23 of these days, valid wind direction data were not available for at least 20 hours. These days were excluded from this analysis. For the remaining 147 days, Figure 17 in Appendix A shows how TSP concentrations varied with the number of hours downwind from the Stauffer facility. According to Figure 17, on days when winds blew from the Stauffer facility toward the Ancloste Road monitoring station for at least 13 hours, the measured TSP concentrations were more than 30 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) higher than the levels measured on days when no winds blew from the facility toward the monitoring station. This increase in concentration was statistically significant.

Between 1982 and 1984, on the other hand, the number of hours per day that winds blew from the Stauffer facility toward the Ancloste Road monitoring station had little impact on the measured TSP concentrations (Figure 18, Appendix A), and no statistically significant concentration differences were observed. The contrast between Figures 17 and 18 demonstrates that Stauffer's particulate emissions affected air quality at the Ancloste Road monitoring station, but the magnitude of this impact was considerably less than that for sulfur dioxide levels.

Unlike sulfur dioxide concentrations, whose levels were determined almost entirely by Stauffer's emissions, TSP concentrations appear to result from many emission sources. As Figure 18 shows, for example, the average TSP concentration at the Ancloste Road monitoring station was $69 \mu\text{g}/\text{m}^3$ on days between 1979 and 1981 when winds did not blow from Stauffer's direction. This observation suggests that other local emissions sources (e.g., other industry, wind-blown dust, mobile sources) accounted for a large portion of the measured TSP levels. Curiously, between 1982 and 1984, the average TSP concentration was only $49 \mu\text{g}/\text{m}^3$ on days when winds did not blow from the direction of Stauffer. It is unclear why this average concentration changed between the two time periods. One possible explanation for this change is that particulate emissions from another facility in the area also decreased considerably after 1981. Another possible explanation is that other meteorologic conditions that affect TSP concentrations (e.g., wind speed, precipitation) might have been significantly different between the 1979–1981 and 1982–1984 time frames.

3.3.3.3. Air Quality Modeling Analysis

ATSDR conducted an air dispersion modeling analysis to better characterize past exposures to air emissions from the Stauffer facility. The goal of the analysis was to predict the magnitude and spatial distribution of ambient air concentrations (both acute and chronic exposure durations) that

resulted from Stauffer's air emissions, especially for locations for which no air monitoring results are available, such as the Gulfside Elementary School. ATSDR will use the predicted ambient air concentrations to estimate past exposures to Stauffer's air emissions and to make public health conclusions regarding these exposures.

3.3.3.3.1. Modeling Approach

3.3.3.3.1.1. Background

- ***Site-specific emissions and ambient air monitoring data.*** ATSDR retrieved all readily available site-specific emissions data and ambient air monitoring data. ATSDR considered the emissions data for modeling inputs, and the ambient air monitoring data for conducting model performance evaluations. Emissions data (both measured and estimated) are available for only four pollutants: sulfur dioxide, fluorides, phosphorus pentoxide, and particulate matter. The particulate matter data do not specify particle size fractions, although the stack test data do report relative amounts of soluble and insoluble particles. The available emissions measurements focus entirely on a limited number of point sources (or stacks) at the former facility. Specifically, stack tests were conducted on Stauffer's boilers, the rotary kiln stack, the stack from the nodule cooler, the coke dryer, the furnace tap hole scrubber, and the phosphorus condenser. Although Stauffer's air permits required annual stack tests for most of these sources, only a small subset of the stack test results were retrieved. Later discussions in this modeling approach section present additional information on the available data and identify the many air pollution sources at Stauffer that were never characterized (e.g., all fugitive emissions).

During the time Stauffer operated, ambient air monitoring data of known and high quality are available only for sulfur dioxide and total suspended particulates (TSP). The most reliable data were collected by the PCDEM to assess attainment with EPA's National Ambient Air Quality Standards. The area surrounding Stauffer was the only sulfur dioxide nonattainment area in the entire state of Florida. Continuous sulfur dioxide monitoring (reported as 1-hour average concentrations) occurred during 4 years of Stauffer's operation, and TSP monitoring occurred on a 6-day schedule during 4.5 years of Stauffer's operation. Stauffer measured air concentrations of phosphorus pentoxide and fluorides in several field surveys, but the quality of these sampling results is questionable. Ambient air monitoring data are not available for any other pollutants.

- ***Other sources of emissions data.*** In addition to reviewing emissions data specific to the Stauffer facility, ATSDR considered emissions data published for the elemental phosphorus production industry. For instance, ATSDR obtained and reviewed chapters from EPA's AP-42 (EPA 1995b) and corresponding background documents. ATSDR also accessed chemical speciation profiles for relevant source categories from EPA's SPECIATE database (EPA 2002b). ATSDR also reviewed emission inventory data for

two elemental phosphorus production facilities in Idaho that the agency evaluated in the past: a facility previously operated by Monsanto in Soda Springs and a facility previously operated by FMC in Pocatello. ATSDR considered, but did not necessarily use, information from these additional sources when formulating this modeling approach.

3.3.3.3.1.1.1. Source characterization: emissions. In general terms, phosphorus production facilities separate elemental phosphorus from a phosphorus-rich ore. All other components in this ore become waste products, either as solid waste or air emissions. These facilities have multiple unit operations, all of which can release numerous contaminants to the air. Modeling the air quality impacts from these facilities requires detailed emissions data from the various operations. However, a comprehensive emissions inventory has never been prepared for the Stauffer facility, most likely because the facility ceased operations in 1981, several years before environmental regulations focused on air emissions of contaminants other than criteria pollutants.

To characterize air emissions from the Stauffer facility, ATSDR reviewed numerous site documents, including air permits, stack test results, and emissions disclosure statements. A critical issue in this modeling analysis is whether the data in these documents are representative of the actual emissions from Stauffer. This section lists the contaminants that Stauffer likely emitted and reviews the emissions data available for the various sources that released them.

For each contaminant, ATSDR considered whether modeling should be conducted. Although it is desirable for modeling to evaluate as many contaminants as possible, this desire must be weighed against the considerable uncertainties associated with estimating emissions from the former facility.

- **Sulfur dioxide.** Unit operations that combusted fossil fuels and exposed phosphate rock to high temperatures emitted sulfur dioxide. These emissions occurred almost entirely through stacks, and fugitive emissions were likely insignificant. Several site records document measured and estimated emissions from Stauffer's boilers, rotary kiln, condenser, and furnace. Emissions from the boilers and rotary kiln account for 99.8% of the facility's emissions.

ATSDR included sulfur dioxide in the modeling analysis primarily because the emissions have been extensively characterized and because a large volume of ambient air monitoring data are available for model performance evaluations. ATSDR did not consider photochemical reactions, however, because the amount of sulfur dioxide consumed in the reactions over the modeling domain is believed to be insignificant.⁹ Table 27 in Appendix B lists the emission rates that ATSDR used for this modeling

⁹According to ATSDR's *Toxicological Profile for Sulfur Dioxide* (ATSDR 1998), less than 5% of airborne sulfur dioxide converts to other products per hour. Because Tampa has an average wind speed of 8.3 miles per hour, the amount of sulfur dioxide that would chemically convert within the modeling domain (2 square miles) would likely be on the order of 1%.

analysis. The modeling focused on the two sources that accounted for the overwhelming majority of Stauffer's sulfur dioxide emissions.

- Particulate matter.* Many sources at Stauffer emitted particulate matter. To fulfill air permit requirements, Stauffer measured particulate matter emissions from its boilers, rotary kiln, nodule cooler, furnace tap hole scrubber, coke dryer, condenser, and a baghouse used to control emissions from materials handling. Emissions data for these sources are reported as "total particulates," without providing any information on particle sizes. Stack test results are available only in summary form, without descriptions of stack test methods that would allow inferences to be drawn about particle sizes. The only information that might be used to assess particle sizes is the amount of 'soluble' and 'insoluble' particles in the emissions. Some stack test results not only reported the total amount of particulate matter in the emissions, but indicated the relative amounts of 'soluble' and 'insoluble' particles. This distinction is made for particles collected in different parts of the stack sampling equipment. Some particulate matter (soluble particles) are captured in impinger solutions, while other particulates (insoluble particles) settle on sampling filters. As a general rule, soluble particles tend to be found in the fine fraction of particulate matter, whereas insoluble particles tend to be found in the coarse fraction. However, no definitive, quantitative statements can be made regarding size cut-offs for soluble and insoluble particles. The available site documents provide no information on fugitive emissions of particulate matter (e.g., wind-blown dust, releases during furnace tapping, materials handling losses), which can be considerable for phosphorus production facilities.
- Fluorides.* ATSDR modeled the atmospheric dispersion of fluoride emissions on the basis of emission rates that Stauffer measured and estimated. Table 27 in Appendix B lists the available emissions data, which consider many, but not all, of the unit operations expected to release fluorides. The data in Table 27 translate into an annual fluoride emission rate of 6.06 tons. This is reasonably consistent with estimates of fluoride emissions from the former FMC facility (26.8 tons per year) and the Monsanto facility (24.7 tons per year), considering the different production levels of the facilities, although ATSDR notes that similarities in emission rates would not necessarily be expected given that the Stauffer and Idaho facilities process different ores. Nonetheless, the modeling results based on the available emissions data can be used to qualitatively assess whether inhalation exposures to fluorides were on the same order of magnitude as ATSDR's corresponding minimal risk levels (MRLs).¹⁰

Largely because of the lack of reliable data on reaction rate constants, ATSDR did not model photochemical reactions involving fluorides. ATSDR's *Toxicological Profile for Fluorides, Hydrogen Fluoride, and Fluorine* (ATSDR 2001), for instance, states that

¹⁰The MRLs for inhalation exposures to fluorides are 0.03 ppm or 30 ppb (25.0 µg/m³) for acute exposure durations and 0.02 ppm or 20 ppb (16.6 µg/m³) for intermediate exposure durations.

“no information was found on the reactions of hydrogen fluoride with common atmospheric species or estimates of its overall atmospheric half-life.”

- *Phosphorus compounds.* Elemental phosphorus production facilities release various forms of phosphorus into the air, including phosphorus pentoxide, phosphates, and phosphine. Other than a single stack test conducted in the early 1970s that measured phosphorus pentoxide emissions from the rotary kiln and the furnace tap hole scrubber, no site-specific information exists for emissions or ambient air concentrations of phosphorus compounds. Moreover, EPA has not published emission factors for these contaminants. The only detailed information available is from the former FMC facility in Idaho, which measured or estimated emissions of total phosphorus and phosphine. Because the representativeness of these data to operations at Stauffer is unknown, ATSDR did not consider phosphorus compounds in the air dispersion modeling analysis.
- *Metals.* The available site records provide no information on amounts of metals in the phosphate rock, in the air emissions, or in the ambient air surrounding the facility. Site-specific data are available on concentrations of metals in solid waste disposal areas, but the usefulness of these data are unclear. Therefore, because emission rates for metals cannot be predicted with confidence, ATSDR decided not to model atmospheric dispersion of metals.
- *Radionuclides.* No detailed site-specific information is available on the levels of radionuclides in the ore or in the emissions. According to EPA's AP-42, however, phosphate rock ore mined in Florida contains radionuclides at concentrations ranging from 48 to 143 picocuries per gram (pCi/g) (EPA 1995b). The “specific radionuclides of significance” are isotopes of uranium, radium, thorium, polonium, and lead. Every emission factor for radionuclides in AP-42 has a poor rating factor, meaning that “there may be reason to suspect that the facilities tested do not represent a random sample of the industry.” EPA gathered additional information on radionuclide emissions when developing the National Emission Standards for Hazardous Air Pollutants (NESHAPs) for this source category, but the representativeness of this information to the closed Stauffer facility is not clear. ATSDR already evaluated potential exposures to radionuclides in Stauffer's solid waste products that were used for various purposes throughout the Tarpon Springs area.
- *Organic compounds.* Emission factors are available to estimate releases of organic compounds from the combustion of fuel. However, elemental phosphorus production facilities are primarily involved in processing inorganic chemicals and materials, and organic chemicals have not been the focus of regulatory attention at other phosphorus production facilities. Therefore, ATSDR did not consider organic chemicals in this modeling analysis.

3.3.3.3.1.1.2. Source characterization: release parameters. ATSDR included the following emissions sources in the modeling analysis: process boilers, rotary kiln, nodule cooler, coke dryer, materials handling operations, furnace, phosphorus condenser, and phosphorus roaster. ATSDR modeled emissions from the rotary kiln with two separate sets of stack parameters to reflect changes made to this source in 1979. Table 28 in Appendix B lists the stack parameters that ATSDR used for the modeling analysis. These parameters were obtained from various data sources, including stack test results, air permits, and inspection records.

3.3.3.3.1.1.3. Model selection and general inputs. ATSDR used the Industrial Source Complex, Short Term (ISCST3) model to conduct the dispersion modeling analysis. EPA recommends using ISCST3 for modeling continuous releases of air contaminants from multiple sources in areas with simple terrain, much like the conditions at Stauffer. The model was run using surface meteorologic data and mixing heights observed at the Tampa International Airport between 1977 and 1981—the last 5 years that Stauffer operated its major production processes. Unit emission rates (1.0 gram per second) were entered for every source, such that ATSDR could later calculate ambient air concentrations for different groups of air pollutants under different emissions scenarios. The model predicted air concentrations for four averaging periods: annual average, highest 24-hour average, highest 3-hour average, and highest 1-hour average. All concentrations were reported in units of micrograms per cubic meter, as is standard for this model.

Ambient air concentrations were predicted for a grid of receptors that extends approximately 5 miles in every compass direction from the Stauffer facility. Receptors were placed at 10-meter intervals along the fence line, at 100-meter intervals at locations within 1 mile of the facility, and at 1,000-meter intervals at locations further downwind. Overall, concentrations were predicted at more than 4,000 receptors. The modeling was run using typical regulatory default options. Building downwash was considered in this analysis; however, detailed information on the locations and heights of Stauffer's buildings was not readily available. The building locations were estimated from facility plot plans and heights were estimated from facility photographs. The most prominent structure considered in this analysis was the furnace building.

3.3.3.3.2. Modeling Results

The dispersion modeling analysis evaluated emissions from only those sources that site documents identified and characterized. These sources were the boilers, the rotary kiln, the nodule cooler scrubber, the coke dryer, a materials handling stack, the phosphorus condenser, and the furnace tap hole scrubber. The rotary kiln was modeled as two separate sources: before and after the May 1979 stack modification. Coordinates of all stacks and buildings were inferred largely from visual inspection of aerial photographs and plot plans, which might have introduced slight error in placing individual features at the Stauffer facility. The magnitude of this error is not known, but likely is not greater than 100 feet for each source. As noted previously, fugitive emissions were not considered because site-specific information is not available on the associated emission rates. Fugitive emissions at other elemental phosphorus production facilities accounted for a large fraction of facility-wide emissions for certain contaminants, such as particulate matter.

The modeling outputs include a normalized concentration at each receptor (4,289 total), for each source considered (8 total), for each year of meteorologic data (5 total), and for each averaging period (4 total). Multiplying these together means that the modeling outputs include 686,240 total observations that are available for data interpretation. This number of observations can be presented and interpreted in countless different ways. This section highlights general trends and key insights from the modeling analysis.

This section presents modeled concentrations for 12 locations that ATSDR selected for further analysis. These locations were chosen only to demonstrate general trends in the predicted concentrations and to communicate results for receptors of interest (e.g., Gulfside Elementary School). For all pollutants considered, the highest predicted concentrations did not occur at these 12 locations; rather, the points of maximum impact were generally along the facility boundary, where exposures would be limited to passers-by and, perhaps, workers. Figure 19 in Appendix A shows the 12 locations selected for further analysis; Table 29 in Appendix B lists coordinates and text descriptions for these locations. Following are detailed results for the three pollutants considered – sulfur dioxide (before and after the 1979 stack modification), fluorides, and particulate matter:

- *Sulfur dioxide (before the 1979 stack modification).* Emissions from the rotary kiln accounted for the overwhelming majority of sulfur dioxide emissions from Stauffer. Before May 1979, the kiln stack was approximately 85 feet tall and 22 feet in diameter. In May 1979, Stauffer modified the stack by increasing the height by 75 feet and decreasing the diameter by 18 feet to enhance atmospheric dispersion of the emissions. The following paragraphs present the modeling results for the time frame before the kiln stack was modified.

As specified previously, this analysis considered sulfur dioxide emissions from two sources: the rotary kiln and the boilers. Emissions from the kiln accounted for 97.0% of the total sulfur dioxide released from these sources. To evaluate the performance of the dispersion modeling evaluation, ATSDR compared the sulfur dioxide concentrations estimated for the Anclote Road monitoring station to those that were measured at this location between July 1977 and May 1979. Table 30 in Appendix B summarizes this comparison. As the first row in the table shows, the predicted annual average concentration was 5.1 ppb lower than the measured levels, which likely results from a combination of the following factors:

- ▶ The model evaluates Stauffer's air quality impacts and does not consider impacts from other sources of sulfur dioxide emissions. As the Table 30 notes explain, the annual average sulfur dioxide levels after Stauffer shut down were 1.42 ppb. Thus, it is reasonable to infer that emissions from other sources account for 1.42 ppb of the 5.1 ppb difference between the predicted and observed concentrations.
- ▶ The emission rates entered into the model do not account for all of the sulfur dioxide that Stauffer released to the air. For instance, the actual sulfur dioxide emission rates from the boiler and the rotary kiln might have been higher than those documented in the stack test results. Additionally, and more likely, emissions

sources not identified in the site documents (e.g., fugitive emissions from furnace tapping) could explain the discrepancy.

- ▶ Air dispersion models have inherent uncertainties and are not perfect portrayals of atmospheric conditions. Even in cases where every model input is known, model predictions will not replicate observed concentrations. Despite these inherent limitations, air quality modeling analyses offer valuable insights into spatial and temporal variations in levels of air pollution, particularly for locations where sampling did not occur.

The second and third rows of Table 30 in Appendix B compare the estimated highest 24-hour average concentration and 1-hour average concentration for the Anclote Road monitoring station to the corresponding measured levels. For the highest 24-hour average concentrations, the comparison is similar to the annual average concentrations, and the differences most likely result for the same reasons listed above. For the highest 1-hour average concentrations, on the other hand, a different trend is observed: the estimated peak concentrations are higher than those predicted. This might have occurred for several reasons:

- ▶ It is possible that the modeling analyses are correct and that 1-hour average sulfur dioxide levels at the Anclote Road monitoring station were at times higher than the levels measured between July 1977 and May 1979.
- ▶ It is also possible that the predicted 1-hour average concentration is based on a highly unusual meteorologic condition reported at the Tampa International Airport that is not truly representative of the conditions at Stauffer.
- ▶ Finally, and most likely, the difference can simply reflect model uncertainty, which increases as concentrations are predicted for shorter averaging periods.

It will never be known exactly what caused the difference between the predicted and observed highest 1-hour average sulfur dioxide levels. However, dispersion models are less reliable at predicting short-term concentrations than at predicting long-term average levels. The fact that the estimated 1-hour peak concentrations ended up being within 30% of the observed levels is actually quite encouraging, as modeled concentrations tend to deviate more and more from observed concentrations for shorter averaging times.

Perhaps the greatest usefulness of this modeling analysis is that the results can be used to estimate ambient air concentrations of sulfur dioxide at locations where they were not measured. ATSDR chose to use the raw model outputs as the estimated concentrations when estimating exposures throughout the Tarpon Springs area. These model outputs were based on emissions data from the boilers and the rotary kiln (e.g.,

the model predicted that Stauffer's contribution to annual average sulfur dioxide levels at Gulfside Elementary School was 7.0 ppb).

In summary, extensive information is available on the sulfur dioxide modeling results that can be used to estimate ambient air concentrations of sulfur dioxide where they were not measured. Although predicted and observed sulfur dioxide levels at the Anclote Road monitoring station differed, the magnitude of this difference is within the bounds of reasonable model performance.

- *Sulfur dioxide (after the 1979 stack modification).* ATSDR also modeled sulfur dioxide concentrations for Stauffer's stack configuration between June 1979 and the time the facility closed. Three key trends are documented here.

First, Table 30 in Appendix B compares the predicted sulfur dioxide concentrations at the Anclote Road monitoring station to the measured levels between June 1979 and November 1981, when Stauffer's furnace was permanently shut down. Consistent with the time frame before the 1979 stack modification, the predicted annual average and highest 24-hour average concentrations were lower than those that were observed, whereas the predicted highest 1-hour average concentration was higher than observed levels. The interpretations of these differences presented earlier in this section also apply here.

Second, ATSDR notes that the model quite reasonably captures the relative changes in sulfur dioxide concentrations (over the long term) caused by the stack reconfiguration. Specifically, the model predicts that the reconfiguration caused annual average sulfur dioxide levels at the Anclote Road monitoring station to decrease by 7.6 ppb; the measurements indicate that sulfur dioxide levels actually decreased by 9.4 ppb. These concentration differences are quite consistent, as far as modeling predictions go, and gives reassurance that the stack reconfiguration truly did account for improvements in air quality after May 1979.

Third, for a sense of the predicted effect of the stack reconfiguration, Table 31 in Appendix B lists the predicted percent decrease in Stauffer's contribution to sulfur dioxide levels that resulted from this modification. The table shows that Stauffer's contribution to sulfur dioxide levels, for all averaging times and most locations considered, decreased between approximately 50% and 75%, although smaller and larger decreases were observed for certain circumstances.

- *Fluorides.* The modeling considered fluoride emissions from four sources: the rotary kiln, the nodule cooler scrubber, the phosphorus condenser, and the furnace tap hole scrubber. Emissions from the rotary kiln accounted for the overwhelming majority (94.3%) of the fluoride emissions. An analysis of Stauffer's stack test data and annual emissions disclosure statements results in the following estimated ambient air concentrations of fluorides at the maximally impacted off-site location:

<u>Averaging Time</u>	<u>Concentration</u>
Annual average concentration	0.41 ppb (0.34 $\mu\text{g}/\text{m}^3$)
Highest 24-hour average concentration	4.6 ppb (3.8 $\mu\text{g}/\text{m}^3$)
Highest 1-hour average concentration	24.6 ppb (20.5 $\mu\text{g}/\text{m}^3$)

In this summary, the annual average concentration is the average concentration for the 5 years of meteorologic data considered. The highest 24-hour average concentration and the highest 1-hour average concentration are the highest predicted levels for the corresponding averaging times, based on the entire 5-year simulation period. These concentrations were predicted using the stack configuration before May 1979; the estimated concentrations for the time frame after May 1979 are more than a factor of three lower than those shown above.

Comparing the modeling results to the MRLs, ATSDR notes that estimated annual-average exposures and 24-hour average exposures are considerably lower than the MRLs, whereas the single highest estimated 1-hour average exposure for the entire vicinity over a 5-year record is less than ATSDR's acute and intermediate inhalation MRL. This comparison suggests that the amount of fluoride emissions from Stauffer's stacks were likely not at levels of health concern.

The most notable limitation of this analysis is that fluorides in Stauffer's fugitive emissions were not considered, because these fugitive emission rates are unknown. To examine this issue further, ATSDR reviewed emissions data from two other elemental phosphorus production facilities that ATSDR evaluated previously. Both facilities are in southeastern Idaho. Emissions data for these facilities suggest that fugitive emissions, particularly from furnace taping, slag handling, and slag cooling, might account for a considerable portion of the facility-wide releases of fluorides. It is not clear, however, how this observation can be factored into this modeling analysis in a scientifically defensible manner.

Although the impact of these fugitive emissions from Stauffer might be impossible to quantify, ambient air monitoring results from one of the elemental phosphorus production facilities in southeastern Idaho provide additional perspective on this matter. These data are available for the Eastern Michaud Flats (EMF) site, which included both an elemental phosphorus production facility and a facility that manufactured phosphate fertilizers. The elemental phosphorus production facility at the EMF site had a production capacity approximately ten times greater than that of Stauffer, and both facilities were believed to emit large quantities of fluorides. During the remedial investigation for the EMF site, 856 air samples were collected and analyzed for fluorides. This sampling spanned an entire year, during which both facilities operated at typical production levels. Samples were collected in areas (including fence line) where air models predicted the highest concentrations would occur. The highest 24-hour

average fluoride concentration measured during this extensive sampling program was $13.1 \mu\text{g}/\text{m}^3$, which is below ATSDR's acute and intermediate MRLs for fluoride.

The air sampling results from the EMF site are somewhat reassuring, because they indicate that ambient fluoride levels in the immediate vicinity of a much larger phosphorus production facility (and a fertilizer manufacturer that also emitted fluorides) were not at levels of health concern. However, a perfect comparison cannot be made between the EMF and Stauffer sites, because several factors determine the amount of fluorides emitted by a given elemental phosphorus production facility. Two factors that have a significant impact on a facility's fluoride emission rates are (1) the fluoride content of the phosphate rock ore, which can vary greatly across different ore deposits, and (2) the facility's process design, including the effectiveness of air pollution controls.

In summary, no studies using reliable methods ever extensively characterized ambient air concentrations of fluorides in the vicinity of Stauffer while the facility was in operation. ATSDR's modeling analysis, which was based on the best available emissions data, suggests that ambient air concentrations of fluorides did not exceed levels of health concern. ATSDR acknowledges that this modeling analysis has limitations, most notably that emissions data were not available for every source at the facility. To evaluate air quality impacts of fluorides further, we also considered our past evaluations of air quality issues at much larger elemental phosphorus production facilities. Very extensive air sampling data for fluorides at these facilities showed no evidence of airborne fluoride concentrations being at levels of concern. This observation is consistent with the findings of our modeling analysis at Stauffer.

- *Particulate matter.* This section presents modeling data for "total particulates" from Stauffer, based on emissions data available for seven sources at the facility. All emissions data were reported for total particulates, without specifying particle size fractions. Because emissions data were collected during the time when most regulatory efforts focused on TSP, the stack tests likely collected particles with size ranges comparable to TSP. Although general statements can be made about particle size distributions for particular sources¹¹, no site-specific data extensively characterized the actual particle size distribution of Stauffer's emissions. However, some site reports indicate that air emissions from the kiln and the furnace—two of the largest point sources of particulate matter—were dominated by fine particles. Deposition was not considered in the dispersion modeling analysis, due in part to the lack of information on the particle sizes emitted from the stacks. Omitting deposition is expected to have only marginal effects on the concentrations predicted for receptors nearest the facility.

¹¹ For example, it is reasonable to assume that air emissions from high-temperature sources (e.g., boilers, rotary kiln, furnace) were predominantly fine particles and that emissions from most fugitive sources (e.g., slag crushing, wind-blown dust) were predominantly coarse particles, but no quantitative information is available for the relative amounts of fine and coarse particles.

Emissions data for total particulates were available only for selected stack sources. These data suggest that Stauffer emitted 242 tons of total particulates from these stacks per year. This figure has been contested because of questions about a possible positive interference in the stack test methodology used for the rotary kiln. Assuming this interference occurred, it is possible that facility-wide stack emissions were actually as low as 150 tons per year. The model was run to estimate air concentrations for both “low emissions” and “high emissions” from the rotary kiln stack to reflect the impact of this debate.

No information is available from the site documents on fugitive emissions of particulate matter (e.g., wind-blown dust, releases during furnace tapping, materials handling losses), which can be considerable for phosphorus production facilities. At the EMF site, for example, an emissions inventory suggests that fugitive emissions accounted for 31% of the total emissions of particulate matter less than 10 micrometers in diameter (PM₁₀) from the elemental phosphorus production facility. The extent to which this factor applies to Stauffer is not known because of differences in the facilities’ unit operations and air pollution controls.

Table 32 in Appendix B presents estimated annual average concentrations of total particulates resulting from Stauffer’s stack emissions. Predictions are made for two time frames and two categories of rotary kiln emissions. Of the 12 receptor locations selected for this analysis, the highest estimated annual average impacts (10.86 $\mu\text{g}/\text{m}^3$ of total particulates, before May 1979, based on the high kiln emission rates) are seen for receptor location 5, which is in the industrial area east of Stauffer. This area, rather than an area downwind, presumably has greater air quality impacts because of building downwash effects. At the Anclothe Road monitoring station (receptor location 8), the modeling results suggest that Stauffer’s stack emissions contributed between 1.63 and 4.36 $\mu\text{g}/\text{m}^3$ to annual average total particulate levels.

Data ATSDR has accessed from EPA’s SPECIATE emissions database suggest that particulate matter emissions from high temperature sources (kilns and furnaces) contain between 87% and 88% fine particles. If this profile applies to Stauffer, then it is possible that Stauffer’s air emissions from point sources contributed up to 4 $\mu\text{g}/\text{m}^3$ of PM_{2.5} at the Anclothe Road monitoring station. This likely understates Stauffer’s actual air quality impacts, because our modeling does not account for all sources of PM_{2.5} (e.g., fugitive emissions from the furnace), nor does it account for secondary formation of particulate aerosols.

Table 33 in Appendix B presents the highest estimated 24-hour average total particulate concentrations resulting from Stauffer’s stack emissions. The data shown in this table represent the highest incremental effect that Stauffer’s stacks had on air quality in a 24-hour period, based on 5 years of meteorologic observations. For instance, Stauffer’s

point source emissions may have accounted for between 27.5 and 75.6 $\mu\text{g}/\text{m}^3$ of the total particulate measured at the Anclote Road monitoring station.

The particulate matter modeling analyses suffer from some notable limitations. These limitations include lack of information on particle size distribution and fugitive emission rates, lack of confidence in the stack emissions data for the rotary kiln, the fact that only a small subset of stack results were identified, the lack of data on temporal variability in emission rates, and the possibility that stack emissions data for sources other than the rotary kiln are not representative of actual conditions. Given the uncertainties in this analysis, ATSDR is using key trends from the monitoring data (e.g., the decrease in TSP levels after Stauffer shut down, the fact that the highest levels of TSP exposure generally occurred on the same days as the highest levels of sulfur dioxide exposure, the fact that particulate emissions from other local sources (e.g., the Florida Power Anclote Plant) accounted for more than half of the TSP detected at Anclote Road) to conduct the public health evaluation. We note in Section 5.3.2, however, that our estimates of air quality impacts based on the monitoring data are reasonably consistent with our modeling predictions, thus giving us some reassurance that the estimated exposure concentrations are reasonably representative of actual exposures.

A number of community members have asked ATSDR about levels of air pollution at Gulfside Elementary School during the time that Stauffer was operating. Unfortunately, no ambient air monitoring data of a known and high quality were collected in the immediate vicinity of the school. As a result, the only means we have to characterize past exposures to students is through computer modeling. As Table 32 shows, our modeling analysis predicted that Stauffer's stack emissions added an additional 2 to 3 $\mu\text{g}/\text{m}^3$ total suspended particulates to background levels at the school. If we assume that emissions from the facility's high temperature sources was between 87% and 88% fine particles, then the model predicts that Stauffer's stack emissions may have caused a 2-3 $\mu\text{g}/\text{m}^3$ increase in $\text{PM}_{2.5}$ levels at the school. This likely underestimates the air quality impacts, because the computer modeling does not account for formation of secondary aerosols (which are typically fine particles) nor does it account for fugitive emissions from the furnace (which are likely primarily fine particles). We can not explicitly account for the atmospheric reactions or the fugitive emissions because the site-specific data needed for such analyses are not available and cannot be reconstructed with confidence. Therefore, we do not know the extent to which we have underestimated concentrations, though it is likely that $\text{PM}_{2.5}$ levels at the school were no higher than what we have predicted for the Anclote Road monitoring station, given that the school was typically upwind from Stauffer. This means that the estimated range of $\text{PM}_{2.5}$ at the school is probably somewhere between 2 and 7 $\mu\text{g}/\text{m}^3$.

ATSDR realizes that Gulfside Elementary School was located close to Stauffer's slag processing operations, which might have had emissions that contributed to exposures for students and staff. The site files we reviewed do not include emissions data for this

part of the facility, nor do they provide any detailed information that would allow us to derive reasonable estimates of the air emissions. Therefore, emissions from these operations are not included in our analysis. We note, however, that emissions from these operations would likely consist of coarse particles, with relatively small contributions from fine particles. Finally, the frequency with which emissions would blow from the slag processing operations toward the school is relatively low; as Section 3.3.3.1 notes, wind directions from south to north occurred during only 4% of the hours that meteorologic observations were collected.

Although the students and staff at the Gulfside School were probably exposed to some increased levels of PM while Stauffer was operating, the lack of good information regarding their PM exposures does not allow ATSDR to determine with any certainty if these exposures constituted a hazard.

3.3.4. Ambient Air Monitoring Data: What Were the Levels of Contaminants in the Air?

This section reviews the history of ambient air sampling studies conducted in the vicinity of the Stauffer site. The studies identified to date were initiated by various parties, including EPA, PCDEM, Stauffer, the Pasco County District School Board, and the Florida Power . The summary is provided for two distinct time frames: the years when elemental phosphorus production occurred at Stauffer, and the years after these production activities ceased. The detailed summaries focus on additional time frames of concern, such as the first years after the Gulfside Elementary School opened and months during which notable demolition activities occurred.

The review is based on site reports obtained through July 2002. These reports largely focus on ambient air sampling, although some indoor air sampling results and personal exposure monitoring results were provided as well. This summary does not review a rather large volume of ozone and nitrogen dioxide measurements collected in northern Pinellas County. These measurements are not reviewed because (a) Pinellas County is an attainment area for EPA's National Ambient Air Quality Standards for these pollutants, (b) sampling data for these pollutants are not available for the time during which Stauffer operated, and (c) because Stauffer emissions alone would likely not have affected local ozone levels.

Following are brief summary statements of the many ambient air sampling studies conducted in the vicinity of the Stauffer facility.

3.3.4.1. Air Quality While the Stauffer Facility Operated (1948–1981)

Table 34 in Appendix B presents key features of the air sampling studies conducted in the vicinity of the Stauffer facility between 1948 and 1981. PCDEM's sampling of sulfur dioxide and particulate matter used well-tested methods, and the sampling results are of a known and high quality. Many of the other sampling studies conducted prior to 1981 are poorly documented and lack important details on data quality. As a result, caution must be used when interpreting these

studies' results. The data quality concerns notwithstanding, sampling results collected during the multiple studies are generally consistent with the following summaries:

- *Sulfur dioxide.* Elevated ambient air concentrations of sulfur dioxide were measured in the immediate vicinity of the Stauffer facility. At PCDEM's Anclote Road monitoring station, 3-hour average and 24-hour average sulfur dioxide levels exceeded EPA's air quality standards from 1977 through early 1979 (see Table 35 in Appendix B.). Consequently, the northwest corner of Pinellas County was designated a nonattainment area for sulfur dioxide. This was the only nonattainment area for sulfur dioxide in the state of Florida. From 1977 to 1981, 1-hour average sulfur dioxide concentrations at the Anclote Road station frequently exceeded 100 ppb. Sulfur dioxide monitoring data collected by Stauffer are generally consistent with the PCDEM's monitoring results, but the quality of Stauffer's sulfur dioxide measurements is unknown.

As shown in Table 35, annual average sulfur dioxide concentrations at the Anclote Road monitoring station decreased significantly in 1979 and again in 1981. These decreases coincide with Stauffer's installation of a taller stack at the rotary kiln scrubber and Stauffer's main production operations shutting down altogether. In fact, the annual average concentration of sulfur dioxide at the Anclote Road monitoring station decreased by more than 90% between 1979 and the years after Stauffer shut down. The most plausible explanation for this trend is that air emissions from Stauffer accounted for a large portion of ambient air concentrations of sulfur dioxide southeast of the facility. Although other air emissions sources of sulfur dioxide operate in northern Pinellas County and southern Pasco County, these sources accounted for a very small fraction (likely less than 10%) of the airborne sulfur dioxide detected at the Anclote Road monitoring station in 1979 and earlier.

The ambient air monitoring data provide limited insights on spatial variations in sulfur dioxide concentrations. The only other sulfur dioxide monitoring data of known and high quality collected before 1982 was from PCDEM's East Lake Tarpon monitoring station, where sulfur dioxide levels did not change considerably after Stauffer operations shut down. This trend suggests that air emissions from Stauffer had minimal air quality impacts at this location 7 miles southeast of the facility. One sulfur dioxide emissions source identified in many site documents is the Anclote Plant that was previously operated by the Florida Power . Although this electricity generating facility clearly emitted far greater amounts of sulfur dioxide than did the Stauffer facility, modeling studies conducted by multiple parties—including consultants to Stauffer—unanimously concluded that the Anclote Plant's emissions have limited impacts on sulfur dioxide levels measured in the vicinity of the Stauffer facility. This is because emissions from the Anclote Plant disperse greatly from the altitude at which they are released (nearly 500 feet) down to ground level.

- *Particulate matter.* PCDEM, Stauffer, and the Florida Power measured ambient air concentrations of particulate matter at many locations in northern Pinellas County and

southern Pasco County while Stauffer operated. PCDEM conducted TSP monitoring at its Anclote Road and East Lake Tarpon stations. At PCDEM's Anclote Road monitoring station, annual geometric mean TSP concentrations ranged from 60.2 to 73.2 $\mu\text{g}/\text{m}^3$ between 1977 and 1981. The highest 24-hour average TSP concentration measured at this station was 224 $\mu\text{g}/\text{m}^3$. These concentrations reflect the air quality impacts of all local sources, including fugitive emissions from the Stauffer site. No sampling studies measured particle size distribution within TSP while Stauffer operated. Although some samples were analyzed in a laboratory for particle characteristics, those analyses were not designed to quantify air concentrations of different particle size fractions. Our specific concern with the filter inspection data is that particles on the TSP filters could well have evaporated, agglomerated, or otherwise changed in shape and size in the months between sample collection and filter inspection in the laboratory. We believe it is likely that the limited filter inspection results do not characterize the size distribution of the particles that were in the air.

After Stauffer shut down its phosphorus production processes in 1981, TSP concentrations at the Anclote Road monitoring station decreased, on average, by 24 $\mu\text{g}/\text{m}^3$. This trend provides two notable insights on air quality in the area. First, emissions sources that ceased operating in 1981 accounted for approximately 32% of the TSP measured at the Anclote Road station. The sources that contributed to this decrease primarily include production-related releases from Stauffer, but might also include sources associated with processing Stauffer's wastes (e.g., nearby slag processing facilities). Second, the data suggest that approximately 68% of the airborne TSP before 1981 originated from sources other than Stauffer, such as other local industry (e.g., the Florida Power Anclote Plant), mobile sources, and wind-blown dust.

At the Anclote Road monitoring station, airborne particulate levels never exceeded EPA's former (pre-1987) TSP air quality standards. However, both 24-hour average and annual average concentrations exceeded Florida's standards. Such elevated levels were measured throughout the state of Florida in the late 1970s and early 1980s. In 1981, for instance, 24-hour average concentrations of TSP exceeded Florida's air quality standard at 45 ambient air monitoring stations across the state. Thus, even though TSP levels at the Anclote Road monitoring station were clearly elevated, these levels were not unusually higher than those routinely measured using similar sampling methods in suburban and urban settings throughout Florida.

The available data provide limited insights on spatial variations in particulate matter concentrations. In 1979 and 1980, annual geometric mean TSP concentrations at PCDEM's East Lake Tarpon monitoring station were 37.4 and 38.4 $\mu\text{g}/\text{m}^3$, respectively. These levels fall within the range of background concentrations reported for rural locations in Florida. Therefore, it is reasonable to infer that Stauffer's emissions had minimal, if any, air quality impacts on the East Lake Tarpon monitoring station, which is roughly 7 miles southeast of the Stauffer facility.

Stauffer and the Florida Power also operated particulate sampling devices in northern Pinellas County and southern Pasco County while Stauffer produced elemental phosphorus. However, original documentation of these sampling studies is incomplete, and the quality of the sampling data and accuracy of the measured concentrations are not known.

- *Fluorides.* Stauffer conducted several air quality surveys between 1964 and 1981 to measure ambient air concentrations of fluorides. Several hundred samples were collected at numerous on-site and off-site locations during this time frame, and only a single 24-hour average fluoride concentration (38.7 ppb) exceeded ATSDR's MRL for acute inhalation exposures (30 ppb). The public health significance of exceeding the acute MRL for fluoride is described in the Public Health Implication section (section 5.4.3.) The quality of Stauffer's fluoride measurements is not known and cannot be assessed from the available information, because the site documents provide no insights on measurement precision and accuracy or on quality assurance measures. As a result, drawing firm conclusions based solely on Stauffer's fluoride measurements is not advised.
- *Phosphorus pentoxide.* Stauffer measured ambient air concentrations of phosphorus pentoxide in several hundred air samples collected during two air quality surveys—one performed in 1964, the other in 1975. Average phosphorus pentoxide concentrations measured during these studies ranged from 0.45 to 3.30 $\mu\text{g}/\text{m}^3$, and the highest 24-hour concentration reported was 18.03 $\mu\text{g}/\text{m}^3$. These concentrations were measured from particulate filter samples and therefore do not reflect contributions from any gaseous phosphorus pentoxide. The data collected during these two surveys is of unknown quality, because critical information on the survey design, quality assurance measures, and analytical methods is not documented in the site reports. As a result, drawing firm conclusions based solely on Stauffer's phosphorus pentoxide measurements is not advised.
- *Other pollutants.* Although pre-1981 ambient air sampling efforts focused only on the previous four pollutants, elemental phosphorus production facilities like Stauffer emit many additional contaminants. Examples include combustion by-products, additional phosphorus compounds (e.g., phosphoric acid and phosphine), and metals. According to site documents reviewed to date, no ambient air samples were analyzed for these other contaminants during the time when Stauffer manufactured elemental phosphorus in Tarpon Springs.

3.3.4.2. Air Quality After Stauffer Operations Ceased (1981–2002)

Table 36 in Appendix B presents key features of the air sampling study conducted in the Tarpon Springs area since the Stauffer facility ceased production in 1981. Most of the ambient air sampling studies conducted since 1981 are well documented, used sampling and analytical methods developed for or approved by federal environmental and occupational agencies, and

followed appropriate quality control and quality assurance procedures. With few exceptions, the data appear to be of a known and high quality. Following are data summaries on sampling results collected during the multiple studies:

- *Sulfur dioxide.* From 1982 to the present, ambient air concentrations of sulfur dioxide at several monitoring locations in northern Pinellas County have not exceeded EPA's health-based air quality standards. Between 1982 and 2001, annual average concentrations at PCDEM's three sulfur dioxide monitoring stations ranged from 0.77 to 4.94 ppb, with the highest levels consistently measured at the East Lake Tarpon station. At these stations, 1-hour average concentrations exceeded 100 ppb no more than seven times per year since 1982. Data collected from Florida Power's ambient air monitoring network also indicate that sulfur dioxide levels have not exceeded EPA's air quality standards.
- *Particulate matter.* Since 1981, EPA, PCDEM, and Stauffer contractors collected more than 1,000 ambient air samples from northern Pinellas County to measure concentrations of different sizes of particulate matter. Sampling was conducted on-site, at a location adjacent to Stauffer, and at a location several miles away from Stauffer. Routine sampling occurred during periods of inactivity at Stauffer, and focused studies were initiated to assess air quality impacts from specific remediation projects. To date, none of the measured PM₁₀ and TSP concentrations exceeded EPA's corresponding health-based air quality standards.
- *Phosphorus compounds.* Both Pasco County District School Board and Stauffer contractors conducted sampling programs to measure ambient air concentrations of phosphorus compounds: elemental phosphorus, phosphoric acid, phosphorus pentoxide. More than 500 measurements have been taken since 1981, primarily during site demolition and remediation activities. Sampling for phosphorus compounds occurred both at on-site locations and at the Gulfside Elementary School. Since 1981, 22 air samples were analyzed for concentrations of elemental phosphorus; it was detected in 4 of these samples, at levels ranging from 2 to 11 $\mu\text{g}/\text{m}^3$. Phosphoric acid was detected in 201 of 552 samples measured for this contaminant. The range of detected concentrations (2.01–4.62 $\mu\text{g}/\text{m}^3$) is lower than EPA's reference concentration (10 $\mu\text{g}/\text{m}^3$). Phosphoric pentoxide was not detected in any of the 10 air samples collected since 1981 that were analyzed for this contaminant.
- *Asbestos.* Contractors to the Pasco County District School Board and Stauffer collected more than 100 personal and ambient air samples to determine whether site remediation activities at Stauffer release asbestos to the air. Asbestos structures were not detected in any of the air samples collected at Gulfside Elementary School (detection limit of 0.005 structures per cubic centimeter). Stauffer contractors conducted a more extensive sampling project using more sensitive methods and found an average asbestos concentration of 0.00024 structures per cubic centimeter around the perimeter of the Stauffer facility.

- *Arsenic, fluorides, and radon.* Only one air sampling study—a month-long EPA site investigation conducted in 1987—analyzed air samples for arsenic, fluorides, and radon at Stauffer. Arsenic and fluorides were not detected in the 12 samples that were analyzed for these contaminants; radon levels in five samples ranged from 0.1 to 2.2 pCi/L. A control sample collected at the site (i.e., analogous to a field blank) contained radon at 1.2 pCi/L.
- *Other contaminants.* The air contaminants released from Stauffer changed dramatically after 1981, when elemental phosphorus production operations ceased. Since 1981, air emissions are most likely limited to wind-blown dust and contaminants released during site demolition and remediation activities. PCDEM's routine particulate monitoring adjacent to Stauffer presumably detected any influences from wind-blown dust, and focused sampling projects by multiple parties have characterized air quality during site demolition and remediation activities. Thus, the available data appear to adequately characterize local air quality since Stauffer's main production operations ceased.

3.4. Physical and Other Hazards

Although ATSDR observed physical hazards during the site visit, access to the main plant site and the slag processing area is closely controlled by fencing and by 24-hour security guards. Therefore, ATSDR believes that the actual risk to trespassers from these physical hazards is negligible.

4. EXPOSURE PATHWAYS ANALYSES

This section summarizes the completed and potential exposure pathways associated with the Stauffer site. As part of the public health assessment process, one of ATSDR's first goals is to identify exposure pathways. Exposure pathways are studied to understand the different ways that contaminants move within and from a site and the different ways that people might come in contact with those contaminants. In short, the purpose of the exposure pathway evaluation is to determine (a) if anyone might come into contact with the environmental media under study; (b) when (how often, over what time period); (c) where; and (d) how. This information alone does not define exposure—it simply helps us to better understand the likelihood of exposures. The exposure pathway information is used together with the environmental data to support the health effects evaluation.

ATSDR obtained information to support the exposure pathway analysis for the Stauffer site from multiple site investigation reports, previously released ATSDR documents, 2000 U.S. Census data, and through communications with local and state officials and community members. The analysis also draws from available environmental and exposure data for air, groundwater, soil and slag, and surface water and sediment that were presented in previous sections of this document. Refer to those sections for detailed descriptions of available environmental data and medium-specific environmental transport information. Throughout this process, ATSDR also closely examines community concerns to ensure exposures of special concern are adequately addressed.

To determine whether nearby residents are exposed to contaminants migrating from the site, ATSDR evaluated the environmental and human components of exposure pathways. Exposure pathways consist of five elements: a source of contamination, transport through an environmental medium, a point of exposure, a route of human exposure, and a potentially exposed population.

An exposure pathway can be eliminated if at least one of the five elements is missing and will never be present. ATSDR categorizes exposure pathways that are not eliminated as either completed or potential. For completed pathways, all five elements exist and exposure to a contaminant has occurred, is occurring, or will occur. For potential pathways, at least one of the five elements is missing, but could exist. For potential pathways, exposure to a contaminant could have occurred, could be occurring, or could occur in the future. Tables 37 and 38 in Appendix B summarize exposure pathway information related to the Stauffer site.

4.1. Completed Exposure Pathways

Table 37, Appendix B, is a summary of the completed exposure pathways at this site.

4.1.1. *Breathing Outdoor Air*

- **Breathing outdoor air is a completed past exposure pathway both on-site and off-site.** When the plant was operational, area residents noticed “haze” and dusts presumed to be emitted from the plant furnace. Residents also expressed concern about emissions

during site activities requiring digging or excavations, particularly slag processing activities. People working at or living near the Stauffer site were exposed to airborne contaminants emitted from the site during those times.

As detailed in ATSDR's evaluation of the nature and extent of air contamination (in the Air Contamination section), air releases have been linked with Stauffer operations and emissions reached off-site locations.

During the years of plant operations, elevated ambient air concentrations of sulfur dioxide were measured in the immediate vicinity of the Stauffer facility. Particulate matter concentrations measured in northern Pinellas and southern Pasco counties were also elevated. However, in the Anclote Road area, it is estimated that nearly 70% of the airborne particulate matter originated from sources other than Stauffer, such as other local industry (e.g., the Florida Power Anclote Plant), mobile sources, and wind-blown dust. Information about the size of the particulate matter was not recorded, making it more difficult to assess health effects. Measured data related to fluorides, phosphorus pentoxide, and other pollutants such as metals are scant and/or of questionable or poor quality, and need to be interpreted with caution. Measured concentrations of sulfur dioxide, particulate matter, phosphorus pentoxide, arsenic, fluorides, and radon in air samples collected after 1981 indicate improved air quality in the area.

4.1.1.1. On-Site Exposures

Plant workers and site remediation workers on the site came in contact with contaminated air during the years of plant operation and during subsequent demolition and site investigation activities. The extent of worker exposure would have depended on each worker's work area (some on-site areas might have been subject to more air contamination than others) and the level of activity (more strenuous activities tend to increase a person's breathing rate). Some worker exposure data (from personal monitors and work area monitors) are available that provide some insights to the type and extent of worker exposures, at least for certain time periods (See section 5.8 for a detailed discussion of these data.)

4.1.1.2. Off-Site Exposures

Because emissions from the site blew off-site, people living, working, and playing in downwind locations came in contact with Stauffer emissions during its years of operation. Again, the extent of exposure would depend on location and activities being conducted. Children and those with preexisting respiratory conditions (e.g., asthma, emphysema) are potentially more sensitive or susceptible populations. In addition, unlike workers, some area residents had the potential for round-the-clock exposures (e.g., if they stayed at home all day).

Analysis of available emissions, meteorological, and air monitoring data confirm that off-site areas were affected by Stauffer emissions. As previously discussed, meteorologic data from 1979 to 1996 show that prevailing winds blew roughly from the northeast to the southwest. This trend suggests that long-term pollutant impacts from Stauffer would likely be greatest at locations

southwest of the facility. The prevailing wind direction notwithstanding, winds also periodically blew from all other compass directions during certain times of the year. Therefore, Stauffer emissions likely had short-term air quality impacts in all compass directions around the site, with the extent of these impacts determined by how often a location was downwind from the facility.

The least prevalent wind direction at all three stations was roughly from the south to the north, which is the direction that would blow Stauffer's emissions toward the Gulfside Elementary School. Even so, children at the Gulfside school are a sensitive population possibly exposed to Stauffer emissions during the years 1977 to 1981. Some concerns also exist about potential emissions from slag processing activities in the area of the site closest to the school. Air quality was not measured at Gulfside Elementary until after 1981; phosphorus and asbestos were the focus of these studies.

4.1.2. Drinking On-Site Groundwater

- Groundwater was used for drinking and industrial purposes on-site in the past (until approximately 1979). Drinking water was drawn primarily from wells within the deeper Floridan aquifer. Therefore, **drinking on-site groundwater is considered a completed past exposure pathway**. Available data, however, show that measured contaminant levels did not exceed health-based CVs in the wells known to have been used for drinking water purposes. The site is now served by public water supplies, which have not been affected by Stauffer.

It can be assumed that workers and visitors drank and washed with water from the on-site potable water supply until the plant was connected to the City of Tarpon Springs water supply in late 1979 or early 1980. The plant's potable water was supplied primarily by wells 5, 12, 13, and 15, with wells 7, 10, and 14 serving as backup. Available sampling data for these wells indicate that a number of contaminants were present, including fluoride, phosphorus, sulfate, and iron. However, the contaminant concentrations were below levels of health concern.

4.1.3. Contacting Surface Soil and Slag

4.1.3.1. On-Site Surface Soil and Slag

- **Contacting on-site surface soil and slag is another completed exposure pathway (past and current).** Contact with on-site soils and slag by the general public or by trespassers is expected to be minimal because the site is completely fenced with 24-hour security. Past plant and remediation workers might have had a greater opportunity to contact contaminated materials. It is not known how much soil and slag people might have come in contact with in the past. Completed and planned cleanup actions are intended to eliminate or prevent possible future exposures. The site is now completely fenced, preventing public access.

Past site activities impacted on-site soils in production, process, and disposal areas. In addition, slag generated during Stauffer operations was stored or disposed of in locations across the site. Soil and slag sampling has been a component of site investigations conducted since 1988, with most sample results from 1988 to 1993.

As detailed in the Soil subsection of the On-site Contamination section, the highest concentrations of site-related contaminants were generally detected in soils collected from the former ponds. Contaminants consistently detected at levels above screening values included antimony, arsenic, cadmium, thallium, fluoride, and radium-226 in soils from both the former pond and main production areas. Sampling in slag processing areas generally contained lower concentrations of site-related contaminants, with the exception of radium-226.

Site workers are the population most likely to come in contact with on-site soil and slag. When the site was in use, the pond “soils” were under water and not accessible. No known sampling of the ponds or the materials below were conducted during the years of plant operation. The extent of contact with other soil and slag materials would be dependent on the nature of the worker activities (e.g., was direct contact with soils required), the type of protective clothing (e.g., gloves), and personal hygiene practices following work activities. The occasional trespasser might have contacted and might continue to come in contact with site soils or slag. Site security, however, has likely limited the number of trespassers on-site.

Historically, the site has been completely fenced south of Ancloste Road and under a security guard’s watch 24 hours per day; however, the area north of Ancloste Road (e.g., the slag storage area, ponds 39 and 52) was accessible to the public (NUS 1991). Because the site is now inactive and secure, exposure potential to site soils is limited to remediation workers.

Proposed cleanup activities (now in the planning and negotiation phase) are intended to prevent possible future exposures to elevated or harmful levels of contaminants in soil or slag.

4.1.3.2. Off-Site Soil (Gulfside Elementary School)

- **Contact with off-site soils also is a completed pathway.** Because of its proximity to the site and the fact that children are an affected population, several studies have focused on characterizing the soils and building materials on the Gulfside Elementary School property. Other than radium-226, no contaminants were detected at elevated levels in school soils. No other off-site soil data are available.

The Gulfside Elementary School opened in 1978. The school is approximately 600 feet from the former slag storage area, directly across Ancloste Road north of the Stauffer site. Predominant wind directions were not in the direction of the Gulfside Elementary School. However, its proximity to the Stauffer site, especially to the slag processing area, warrants close examination (see discussion that follows).

As detailed in the Soil and Slag-Containing Materials subsection of the Off-Site Contamination section, Gulfside soils were tested in studies conducted between 1988 and 1997. No earlier soil sample results are available. Sample results indicate that the surface soils collected on the school property contained lower concentrations of virtually all of the contaminants found at the Stauffer site. Metals and fluoride were detected in surface soils at concentrations well below health-based CVs. Radium-226, however, was consistently detected at levels above its CV. No asbestos was detected.

Sampling of the road materials around Gulfside Elementary School property, as well as the soil beneath the roads and roofing material on the school, all showed concentrations of radium-226 that exceeded the CV. The soil beneath the road also showed concentrations of radon-222 that exceeded concentrations found in the on-site surface soils. All of these building materials contained far lower concentrations of the contaminants found in the on-site slag.

People (especially children) might accidentally ingest soil and dust generated from soils during normal activities. Everyone ingests some soil or dust every day. Small children (especially those of preschool age) tend to swallow more soil or dust than does any other age group because children of this age tend to have more contact with soil through play activities and their tendency for more hand-to-mouth activity. Children in elementary schools, teenagers, and adults tend to swallow much smaller amounts of soil or dust. The amount of grass cover in an area, the amount of time spent outdoors, and weather conditions also influence how much soil contact people have.

No soil sampling data exist in “downwind” areas. Therefore, no definitive statement can be made about other possible off-site soil conditions.

4.1.3.3. Off-Site Slag/Building Materials

- Slag generated by Stauffer processes was stored on-site and used as roadway and building material throughout the nearby communities. Therefore, **contact with slag is a completed exposure pathway**. The amount of direct contact that people have had with slag in these areas is not fully known, but sampling results show relatively low contaminant concentrations compared with on-site conditions. EGR exposures associated with these materials also were measured and determined not to be harmful.

Slag material generated from Stauffer operations was routinely used in the construction of homes, driveways, and roadways in nearby communities. Studies conducted in the late 1990s focused primarily on the levels of EGR emitted from these materials. A few studies also examined slag materials for chemical and radionuclide contamination.

People can be exposed to gamma radiation just by being near contaminated material. Community exposure to gamma radiation was the subject of a recent ATSDR health consultation, which concluded that the combined gamma radiation doses from homes and pavement with phosphorus slag measured for residents near the former Stauffer chemical plant are consistent with background levels and do not pose a health threat to the community (ATSDR 2002).

Off-site sampling studies revealed that road and building materials sampled in the surrounding community contained lower concentrations of contaminants than were found on-site. Only arsenic and radium-226 consistently exceeded CVs in off-site samples. Maximum concentrations of radium-226 were generally found in the roadbed and/or pavement used to construct Bluff Boulevard and Gulfview Road, as well as in a few residential building slabs and driveways. None of the off-site sampling studies found evidence of asbestos.

Because slag was used throughout the community, contact with these materials could occur regularly. However, because most of the slag has generally been bound up in building materials and roadways, any chemical contamination is not expected to be largely bioavailable (that is, in a form that can be easily ingested or absorbed by people). Dusts from these roads and building materials might contain chemicals that were previously found in slag, but the contribution of this to total exposure is believed to be minimal, and would presumably be reflected in the available particulate matter measurements.

4.1.4. Ingesting or Contacting Surface Water and Sediment

- **Ingesting or contacting surface water and sediment are completed exposure pathways because contaminated groundwater from beneath the Stauffer site discharges to the river and people might come in contact with water and sediment when using the river.** The river is used for boating, fishing, swimming, and wading. However, in general, water and sediment samples, especially those collected away from the site (e.g., downstream locations sampled near the mouth of the river) do not show unusually elevated contaminant levels. The highest detected contaminant concentrations in sediment were detected in Meyers Cove. In addition, ingestion of surface water contaminants is likely to be minimal because the river is brackish and is not used as a drinking water source.

As described in the Surface Water and Sediment (Anclote River) subsection of the Off-Site Contamination section, surface water and sediment in the Anclote River has been tested as part of four site-related investigations beginning in 1988 to determine if groundwater discharge or surface drainage have negatively impacted the river. In addition, SMC has been sampling river water in the immediate vicinity of the site (just upstream of the site and in Meyers Cove) at least two times a year since 1987. These sampling results generally indicate elevated contaminant concentrations in Meyers Cove sediments compared with other reaches of the river. Surface water quality does not vary greatly throughout the river. No sampling data exist to provide a picture of river conditions during the years of plant operations.

Children and adults fishing and swimming in the Anclote River are likely to contact the water and, possibly, sediments. Again, the specific activity will dictate how much water or sediment, if any, might actually be taken into the body. For example, during swimming, people might accidentally ingest water from the river. However, the amount of water ingested is expected to be minimal because the brackish nature of the river would cause swimmers to spit out most of the water taken into their mouths. During wading activities or fishing activities (particularly

shellfishing activities), people might have some skin contact with sediments. Because sediments are generally submerged in water, prolonged contact with the skin is not likely. Also, the types of contaminants detected (e.g., metals and other inorganics) are not typically well-absorbed through the skin, further reducing possible exposures.

4.2. Potential Exposure Pathways

For a summary of the potential exposure pathways at this site, refer to Table 38 in Appendix B.

4.2.1 Drinking Off-Site Groundwater

- Most, if not all, private wells in the site vicinity are not located in the direct path of site contaminant flow. However, private wells serving residences and businesses do exist near the site and community members have expressed concern about the safety of their supplies. ATSDR therefore considered **drinking off-site groundwater as a potential exposure pathway (past, current, and future)** in its public health evaluation. In addition, some nearby shallow groundwater wells are used for irrigation and lawn-watering activities. Available sampling data (1988–2002) show a few contaminants at slightly elevated levels in area private wells.
- Planned cleanup actions are anticipated to remove or contain on-site contamination and prevent any potential future movement of groundwater contaminants away from the site. Studies have been initiated (summer 2002) to more fully understand how contaminants might move within the aquifers beneath the Stauffer site and to further define the nature and extent of site contamination.

As detailed in the Groundwater subsection of the On-Site Contaminants section, fairly extensive monitoring of the shallow groundwater beneath the Stauffer site (multiple wells tested from 1985 to 2002) reveals the presence of site-related contamination. Less-extensive testing of the deeper Floridan Aquifer (four wells tested from 1988 to 1993) generally shows few elevated levels of pollutants. The predominant direction of groundwater flow in both aquifers beneath the site is to the south/southwest directly into the Anclote River, suggesting limited potential for pollutants to migrate to off-site water supplies. Nonetheless, ATSDR carefully examined the fairly limited set of sampling data from private wells located several directions and distances from the site to address specific community concerns voiced regarding the quality of area groundwater and to evaluate whether any harmful exposures could be occurring.

Groundwater near the site is used for potable water supplies in residential and commercial/industrial locations. Potable wells are believed to draw water from the deeper Floridan Aquifer. Adults and children drink, cook with, and bathe in water from these private wells. The nearest known residential potable well is 2,500 feet northwest of the site (SMC 2001). Because the river is immediately south/southwest of the site, the closest “downgradient” potable wells are on the other side of the Anclote River in Tarpon Springs. Several commercial wells were identified and sampled immediately east of the site on Anclote Road and Savannah Avenue.

Although public water is available, some private wells are used in a small residential area west of the site, primarily for irrigation purposes. In addition, approximately 20 homes in the Hickory Lane and Cemetery Lane area of the Holiday Utilities service area use private wells.

Contaminant information is available for 38 private wells. Some data were collected as early as 1988 as part of site investigations, but most sampling was conducted between 1999 and 2001 by FDOH in association with its underground storage tank program and in response to private well owner requests. Sampling results revealed arsenic, chromium, lead, nickel, thallium, zinc, chlorides, sulfate, gross alpha radiation, and radium-226 at levels above ATSDR CVs, but at relatively low frequencies and most at concentrations well within an order of magnitude of CVs.

4.2.2. Contacting On-Site Subsurface Soils

- **Contact with on-site subsurface soil is a potential future exposure pathway.** Some contamination has been detected in deeper soils (greater than 6–12 inches below the ground surface) in the main processing area, beneath the slag piles, and near former disposal ponds. No past or current exposures exist because these soils are not accessible. Future excavations could result in exposure to workers; however, site cleanup plans still under negotiation will be developed and implemented to prevent future exposures.

As described in the Other On-Site Soils subsection of the Soil section, sampling of the subsurface soils on-site generally showed lower concentrations of contaminants compared with on-site surface soils. However, evidence shows that contaminants associated with site operations, particularly metals and fluoride, are elevated in some subsurface soils. The samples with the highest concentrations of contaminants in the subsurface soil were obtained mainly from the northeast property and along the western portion of the main production area.

People cannot currently come in contact with subsurface soils, but could potentially in the future should site soils be excavated or otherwise disrupted. Remedial workers would be the most likely group of people to come in contact with excavated soils. It is expected that any such excavations would be performed as part of site clean-up activities, under which the proper protection of workers and safe disposal or treatment of contaminated soils would be required.

4.2.3. Eating Fish/Shellfish (Biota)

- **Eating fish is a potential exposure pathway (past, present, and future).** Although the site-related contaminants found in water and sediments are not generally expected to build up in fish, no testing of Anclote River fish/shellfish tissue has been done to lend support to this premise, despite recommendations by past investigators to conduct benthic studies and metal analysis in fish tissue.

Harvesting fish and shellfish from the Anclote River has been, and continues to be, a popular activity. Specific counts on the amount of recreational-caught fish in the site area are not

available. Further, no sampling data are available that specifically characterize the quality of the fish and shellfish in the Anclote River or in the Gulf of Mexico near the mouth of the Anclote River. ATSDR contacted FDEP, FDOH, FFWCC, and Florida Marine Research Institute to learn about fish surveys and counts in the local area. None of these contacts were aware of any relevant fish sampling data.

Descriptive surveys of the river have been conducted over the years, but do not provide useful human exposure data. For example, the University of South Florida conducted a study in 1970–1974 that evaluated the composition, abundance, and distribution of aquatic life in the Anclote River (ranging from bacteria to plankton to benthic organisms [e.g., worms, clams] to fish) (Weston 1989). More recently, FDEP's Surface Water and Assessment Monitoring Program conducted a biological assessment of the Anclote River watershed in 1997 that focused primarily on nutrient levels far upstream of the site (FDEP 1998).

FDOH issued a health advisory for the Anclote River including the Tarpon Springs area in Pinellas County (FDOH no date). The advisory, which is based on mercury contamination in fish, is not related to the Stauffer site. FDOH advises that adults should limit consumption to one meal per week. FDOH also advises that children under 15 years of age and nursing or pregnant women should limit consumption to one meal per month. Fish included in this advisory are largemouth bass, bowfin, and gar. FDOH has information about all Florida fish consumption advisories (FDOH no date), and includes more information on the work of FDOH, FFWC, and the FDEP with regard to mercury in freshwater fish around the state.

Some inferences can be made about the potential impacts of water and sediment contamination on fish by reviewing surface water and sediment data to determine the frequency of detection and the concentrations of site-related contaminants. These data can be compared with water or sediment quality criteria,¹² and focus on contaminants that are likely to accumulate in edible parts of fish.

Available sampling data indicated some elevated contaminant concentrations at varying frequencies in surface water and/or sediment in different reaches of the river. Contaminants of potential concern include some metals, fluoride, phosphorus, sulfates, radium-226, and gross alpha and beta radiation. No widespread contamination of the river is indicated, but some higher concentrations of Stauffer-related contaminants were reported in Meyers Cove.

On the basis of information ATSDR was able to collect, most of the chemicals detected, including fluoride, would not be expected to accumulate in fillet portions of fish and be a problem. This includes past exposure to fluoride releases from the Stauffer facility.

Some people might be concerned about arsenic accumulation in fish. Fish absorb inorganic arsenic from water and sediment and rapidly convert it to an organic arsenic. The most common

¹²EPA recommends pollutant concentrations in water that are considered to ensure the safe consumption of fish living in that water. EPA's water quality criteria are based on data and scientific judgments on the relationships between pollutant concentrations and human health effects.

organic arsenic formed is called arsenobetaine. This is a natural process in fish, and many fish (especially saltwater fish) have high levels of arsenobetaine. Arsenobetaine is not harmful to people because it is easily and quickly eliminated from people's bodies through urine.

5. PUBLIC HEALTH IMPLICATIONS

5.1. Introduction

In conducting the evaluation of exposure to contaminants from the Stauffer facility, ATSDR reviewed the scientific literature for particulate matter, sulfur dioxide, fluorides, and other contaminants. For sulfur dioxide, fluorides, and most other contaminants, ATSDR relied on its toxicological profiles, which summarize pertinent toxicity data from animal and human studies. In addition to the toxicological profiles, ATSDR also used recently published scientific reports. Because ATSDR does not have a toxicological profile for particulate matter, the agency used published scientific literature about the harmful effects of particulate matter.

To evaluate exposure from breathing contaminants in air, ATSDR develops inhalation MRLs when sufficient human or animal studies are available. MRLs are available for three exposure periods: acute for exposure periods up to 14 days, intermediate for exposure periods of 15 to 364 days, and chronic for exposure periods greater than 1 year. Therefore, a chemical can have acute, intermediate, and chronic MRLs if sufficient scientific studies are judged to be available for those periods. An inhalation MRL is the concentration of a chemical in air below which noncancerous harmful effects are unlikely. The concentration unit for an inhalation MRL is either parts of chemical per billion parts of air or milligrams of chemical per cubic meter of air (mg/m^3). For example, if ATSDR developed an acute, inhalation MRL of 10 ppb for a chemical and the chemical's measured concentration in air is 5 ppb, then people could be exposed to 5 ppb of the chemical and noncancerous harmful effects are not likely. It is important to realize that MRLs cover only noncancerous effects, even for chemicals that can cause cancer. For cancer-causing chemicals, ATSDR also uses a mathematical method developed by EPA to estimate a numerical cancer risk as well as biomedical judgement for evaluating cancer risk qualitatively.

Exceeding an MRL, however, does not mean that harmful effects will occur. Exceeding a MRL means that a more thorough toxicological evaluation is necessary. Examples of some factors that are considered as part of a more thorough evaluation include the following:

- Comparing the chemical concentration in air to concentrations that cause harmful effects to determine how close the concentrations are,
- Determining who is exposed and if they are more sensitive to the chemical,
- Evaluating the location of the air sample in relation to where people live,
- Determining if the toxicological effect in study is applicable to the people who are exposed,
- Considering different aspects of exposure in the study (e.g. dosing period, amount, frequency of exposure) and the applicability of those aspect to people who live near the site and their exposure,

- Considering the effect of uncertainty in exposure estimates, and
- Considering the effect of uncertainty in deciding possible harmful effects.

After conducting its site-specific toxicological evaluation, ATSDR describes whether or not people who are exposed to site contaminants might experience harmful effects from that exposure. As part of this discussion, ATSDR also describes the uncertainty that usually exists in making these decisions.

ATSDR has a series of reports that summarize the scientific literature for the interaction of certain groups of chemicals. For instance, ATSDR has an Interaction Profile for Arsenic, Hydraxines, Jet Fuels, Strontium, and Trichloroethylene. ATSDR does not have an interaction profile for particulates and sulfur dioxide. Nevertheless, some information is available about acidic particulates and that information is summarized in section 5.3.5.

In general, the ambient air monitoring data described in the previous sections indicate that some people who lived near the Stauffer facility when it was operating were exposed to some site-related air contaminants, including sulfur dioxide and particulate matter (as measured or estimated by TSP, PM₁₀, and PM_{2.5}). It is important to note that the outdoor air monitoring results are used in this public health assessment as a surrogate for exposure to air pollutants in the area of the Stauffer facility. Actual individual exposure to air pollutants is determined by a complex interplay among human activity, including the locations where time is spent, housing characteristics (as they influence penetration of outdoor pollutants), and other factors.

5.2. Exposure to Sulfur Dioxide in Air and the Possibility of Harmful Effects

ATSDR has outdoor air measurements for sulfur dioxide in the Stauffer area from 1977 through most of the 1990s. These data form the basis of ATSDR's evaluation to determine the possibility of harmful effects occurring in residents (both adults and children) who live near the Stauffer facility.

5.2.1. Historical Air Exposure When Stauffer Was Operating

Stauffer began operations in the 1940s and stopped production by 1982, and ATSDR has outdoor air monitoring data from the second half of 1977 through 1981 while Stauffer was operating. These data were summarized previously in the Air Contamination subsection of the Environmental Contaminants and Other Hazards section; therefore, this discussion will highlight only certain parts of those data.

5.2.1.1. Sulfur Dioxide Levels and ATSDR's MRL

Using the hourly data available from the Anclothe Road monitoring station, ATSDR has calculated the average sulfur dioxide levels for the following time frames: 1 hour, 3 hours, 24 hours, and 1 year. The data for these measurements are summarized in Table 35, Appendix B.

At this time, we will focus on the average sulfur dioxide levels for a 1-hour period. For most of the 4½ years that air monitoring results are available, hourly measurements are available for most of the 24 hours in each day. With 365 days in a year, 8,760 (24 × 365) hourly air measurements are possible in a year. Table 39 in Appendix B highlights the number of hourly measurements for the number of hourly samples and days that sulfur dioxide levels were above 10 ppb, ATSDR's acute MRL for sulfur dioxide. The number of hourly samples in a given year is less than 8,760 because for some days or for parts of some days, air samples were not collected. In 1977, air samples were collected for only the second half of the year.

ATSDR has an acute (i.e., less than 14 days) inhalation MRL for sulfur dioxide of 10 ppb. The acute MRL is used to determine whether sulfur dioxide levels should be evaluated further. Table 39 in Appendix B is a summary of average hourly sulfur dioxide levels at the Anclo Road monitoring station during the years that Stauffer operated. The information in Table 39 shows that over the 4½ years of monitoring:¹³

- Average hourly air levels exceeded the acute MRL of 10 ppb for 3,467 hours out of a possible 34,782 hours, or about 1 out of every 10 hours.
- On 809 days (out of a possible 1,642 days) at least 1 average hourly air sample exceeded the acute MRL of 10 ppb.
- On average, the MRL of 10 ppb was exceeded at the Anclo Road monitoring station on 1 of every 2 days for at least 1 hour.

It should be emphasized that exceeding an MRL does not mean that harmful effects are likely because MRLs are set below the levels that are known to cause harmful effects. Exceeding an MRL means that further toxicological evaluation is needed. To conduct this more thorough toxicological evaluation, ATSDR used data from its *Toxicological Profile for Sulfur Dioxide* (ATSDR 1998) as well as recently published human and animal studies to determine whether or not people in the Tarpon Springs area might experience harmful effects from sulfur dioxide. A brief review of the pertinent human and animal studies on the effects of sulfur dioxide following brief exposures can be found in Appendix E.

A review of the toxicological literature for sulfur dioxide shows that the lowest sulfur dioxide level that is known to cause harmful effects in humans is 100 ppb after exposures of just a few minutes. At 100 ppb, these harmful effects have only been observed in people with asthma who were exercising and breathing through a mouthpiece. The same harmful effects have been observed in exercising asthmatics who were exposed to 250 ppb sulfur dioxide in a chamber (rather than via a mouthpiece). At 100 ppb, the effects observed in exercising asthmatics were an increase in airway resistance in the lungs (that is, bronchoconstriction). It should be noted that these effects are temporary and go away after the exposure stops.

The effects on airway resistance become more pronounced with increasing sulfur dioxide levels to the point that wheezing and shortness of breath can occur when sulfur dioxide levels reach about 500 ppb. It should be noted that some asthmatics who participated in experiments with sulfur

¹³The number of observations in 1977 is less than in 1978 because air monitoring started mid-year in 1977.

dioxide at 500 ppb required the use of bronchodilators to relieve the wheezing and shortness of breath caused by sulfur dioxide exposure. A more detailed review of the harmful effects of sulfur dioxide exposure can be found in Table 40 and Appendix E.

It should be noted that other triggers also exist for asthma. For example, air pollution, tobacco smoke, dust mites, animal dander, molds, and pollen are a few triggers listed at the following websites for the American Lung Association: <http://www.lungusa.org/asthma/astatrigger.html> and <http://www.lungusa.org/asthma/asctriggers.html>. The American Lung Association specifically lists sulfur dioxide as a trigger for asthma.

5.2.2. Sulfur Dioxide Levels Near Stauffer

Results from the Ancloste Road monitoring station show 601 hours out of the 34,782 hours when data are available from July 1977 to December 1981 had hourly average sulfur dioxide levels that exceeded 100 ppb (see Table 41, Appendix B). Table 41 also shows that of the 1,642 days monitored, 210 days had at least 1 hour when average sulfur dioxide exceeded 100 ppb.

Figure 20 in Appendix A shows hourly sulfur dioxide levels at the Ancloste Road monitoring station for the 4½ years when the facility was operating and sulfur dioxide levels were being measured. Because such a long time frame is being presented, only levels above 100 ppb are reported in Figure 20.¹⁴ The data show that periodically very high sulfur dioxide levels were detected from July 1977, through 1978, and up to May 1979. In May 1979, the stack height for the kiln was raised, and, although significant sulfur dioxide levels were still detected occasionally at the Ancloste Road monitoring station, the levels were much lower than those before May 1979. Although it is not clear from Figure 20, several days can elapse between spikes in sulfur dioxide levels. The highest sulfur dioxide level reported was a hourly average of 840 ppb on April 15, 1979.

Several points can be inferred from the hourly average sulfur dioxide data collected from July 1977 to December 1981:

- The highest hourly sulfur dioxide levels were more frequent in 1977, 1978, and the first quarter of 1979 (through April).
- Hourly sulfur dioxide levels were less frequently elevated after May 1979.
- On days with elevated sulfur dioxide levels, levels were sometimes elevated for several hours in a row.
- Hourly sulfur dioxide levels exceeded 500 ppb on 20 days from July 1977 through May 1979.
- Hourly sulfur dioxide levels did not exceed 500 ppb after May 1979.
- The highest hourly sulfur dioxide level detected was 840 ppb on April 15, 1979, at the Ancloste Road monitoring station.

¹⁴100 ppb is chosen here because it is the lowest level of sulfur dioxide that has been shown to cause an adverse effect in humans. A description of the harmful effects caused by sulfur dioxide at various levels in air can be found in Appendix E.

When sulfur dioxide levels were elevated, sometimes they were elevated for several hours at a time. Figure 21 in Appendix A shows sulfur dioxide levels on December 18, 1977, when hourly average levels remained elevated for 14 hours at the Anclothe Road monitoring station. During this time, hourly sulfur dioxide levels were elevated from 7:00 AM to 9:00 AM and again from 1:00 PM to 11:00 PM on December 18, with a final spike at 1:00 AM on December 19.

In another incident on January 13–15, 1978, average hourly sulfur dioxide levels remained significantly elevated at the Anclothe Road monitoring station, showing a variable pattern with both brief and extended elevations (Figure 22, Appendix A). These exposures to elevated sulfur dioxide levels were significant because high exposures continued for 15 of 19 hours.

At other times, hourly sulfur dioxide levels were elevated for only an hour or for just a few hours. This pattern is evident in Figure 23, Appendix A, when in a 24-hour period, sulfur dioxide levels were significantly elevated only from 2:00 PM to 4:00 PM. It is important to realize the average sulfur dioxide level reported for an hour is likely to represent variable sulfur dioxide levels over 60 minutes. This is the case if a cloud of sulfur dioxide passes the air monitoring station in 15 minutes but the levels are measured and averaged over 60 minutes. It has been reported that particulate clouds impacted the Flaherty Marina in Pinellas County for 5 to 15 minutes at a time (PCDEM 1979). It is reasonable to assume that the same is possible for sulfur dioxide clouds.¹⁵ This means that a hourly average sulfur dioxide level of 260 ppb might have a peak concentration in the cloud of about 1,000 ppb if the cloud passed the monitoring station in 15 minutes.

It also is important to realize that the Anclothe Road monitoring station would pick up increased levels of sulfur dioxide only when wind was blowing toward the southeast, thus carrying sulfur dioxide from the Stauffer facility to the monitoring station. If wind was blowing in another direction, elevated sulfur dioxide levels were not likely to be detected at the Anclothe Road monitoring station but rather in the downwind direction away from the monitoring station.

To determine how frequently sulfur dioxide levels might have been elevated in other areas around Stauffer, ATSDR compared (a) the number of hours that wind blew toward the Anclothe Road monitoring station to (b) the number of hours that sulfur dioxide levels exceeded 100 ppb when wind was blowing toward the Anclothe Road monitoring station. This comparison allows ATSDR to estimate how often (i.e., the frequency) sulfur dioxide levels were above 100 ppb when wind blew in another direction with sulfur dioxide levels above 100 ppb.

¹⁵This assumption is likely to be true if sulfur dioxide emissions from the facility vary during brief periods of the day: for example, if sulfur dioxide emissions from the facility are low for most of the day and because of some activity at the plant, sulfur dioxide emissions increase for very short periods (e.g., 10 minutes, 30 minutes). When air was blowing toward the southeast, these sporadic releases would likely have resulted in a plume of contaminated air passing by the air monitoring station. If the plume passed the station in 30 minutes, then maximum levels in the plume would be significantly greater than the average level measured over 60 minutes.

Because of limited data, this comparison could only be made for 1979, 1980, and 1981, the years for which wind direction **and** hourly sulfur dioxide levels were available. In addition, the frequency was determined for January to May 1979 because at the end of May Stauffer raised the stack for the kiln. Because the kiln was the major source for sulfur dioxide emissions, raising the stack likely affected the frequency at which the Anclothe Road monitoring station captured elevated sulfur dioxide levels. Therefore, the frequency of elevated sulfur dioxide levels at the Anclothe Road monitoring station before May 1979 was probably higher than after May 1979.

Table 42 in Appendix B shows the number of hours that wind blew toward the Anclothe Road monitoring station and the number of hours that average hourly sulfur dioxide levels exceeded 100 ppb. As expected, the frequency that elevated hourly sulfur dioxide levels was highest occurred from January to May 1979; specifically, 48 of the 720 hours (or 6.7% of the time) that wind blew toward the Anclothe monitoring station. Another way of thinking about what 6.7% means is that when wind is blowing in a particular direction from Stauffer, about 6 to 7% of the time it will have hourly sulfur dioxide levels above 100 ppb. Stated yet another way, for every 1,000 hours that wind blows in a certain direction, 60 to 70 hours are likely to have hourly sulfur dioxide levels above 100 ppb.

After raising the kiln stack, the percent of time that sulfur dioxide levels exceeded 100 ppb dropped to 57 of the 1,577 hours (or 3.6% of the time) that wind blew toward the monitoring station. Slightly lower percentages are found for 1980 (3%) and 1981 (1.7%) and probably reflect not only the raised stack but also the decreased production at Stauffer.

Figure 24 in Appendix A shows the location of the kiln and the Anclothe Road monitoring station, which is about 1,540 feet southeast of the kiln. Figure 24 also shows a circle 1,540 feet away from the kiln in every direction. It is reasonable to assume that sulfur dioxide levels measured at the Anclothe Road monitoring station will be similar to levels that might be found at other directions from the kiln and at the same distance of 1,540 feet. As seen in Figure 24, other areas that might have similar sulfur dioxide levels as the Anclothe Road monitoring station include the following (only those areas or buildings built before 1982)¹⁶:

- The Flaherty Marina,
- Residential homes southwest of the Stauffer facility along the shore of the Anclothe River,
- Residential homes west of the Stauffer facility, and
- Commercial and industrial businesses east of the Stauffer facility along Anclothe Road.

With the information in Table 42, Appendix B, and using known wind direction in other directions, it is possible to estimate the number of hours that sulfur dioxide levels exceeded 100

¹⁶The approach used to estimate the frequency of elevated exposures to Stauffer's emissions assumes that the facility accounted for all of the sulfur dioxide levels measured in the air near the site. To a first approximation, this is a reasonable assumption, and is supported by modeling analyses previously conducted by multiple parties. ATSDR also used outputs from its modeling analyses to assess the public health implications of exposure to sulfur dioxide.

ppb in other wind directions. It is important to remember that this information applies to a distance of 1,540 feet from the kiln—the distance from the Anclothe Road monitoring station to the kiln.

Table 43 in Appendix B contains information about the frequency at which these other areas around Stauffer might have been exposed *from January to May 1979* to hourly sulfur dioxide levels that exceeded 100 ppb. Table 43 shows the following:

- Other areas that are within 1,540 feet of the kiln,
- The number of hours that wind blew in those directions, and
- The estimated number of hours that wind blew in those directions and sulfur dioxide levels exceeded 100 ppb.

Only people who lived or visited these areas when Stauffer was operating were at risk for exposure. The 100 ppb exposure level applies to a distance of 1,540 feet from the kiln. Air monitoring data are not available for distances beyond 1,540 feet; therefore, these areas will be evaluated later in this report using an air dispersion model to estimate sulfur dioxide levels farther away from the kiln.

To interpret the information in Table 43, for example, people who lived southwest of the Stauffer facility along the shore of the Anclothe River were likely to have been exposed to sulfur dioxide levels greater than 100 ppb for 52 hours between January and May 1979. People who lived farther away were likely exposed less frequently to hourly sulfur dioxide levels exceeding 100 ppb. An estimate of their exposures will be conducted in the air modeling evaluation.

It is important to realize that if a person lived within 1,540 feet of the Stauffer kiln (in any direction), he or she would have been exposed periodically throughout the year to significantly elevated levels of sulfur dioxide. The point is that although some uncertainty exists about the actual number of hours a person was exposed, the values in Table 43 are probably close to the actual number for the 5-month period for which data were available. In previous years, the actual amount of time a person was exposed was probably about twice the number of hours presented in Table 43 because the hours in Table 43 only cover 5 months. These estimates provide insight into the general amount of time that someone might have been exposed to sulfur dioxide levels that cause harmful effects.

5.2.3. Possible Harmful Effects from Sulfur Dioxide in Residents

5.2.3.1. Short-Term Exposures to Sulfur Dioxide

People who lived, worked, or visited the following areas when Stauffer was operating were at risk for harmful effects from exposure to sulfur dioxide (only those areas or buildings built before 1982):

- The Flaherty Marina,
- Residential homes southwest of the Stauffer facility along the shore of the Anclothe River,

- Residential homes west of the Stauffer facility, and
- Commercial and industrial businesses east of the Stauffer facility along Ancote Road.

These exposures could have lasted for a couple of hours or many hours. Table 43 in Appendix B shows the estimated number of times that hourly sulfur dioxide levels exceeded 100 ppb; Figures 20 and 21 in Appendix A show that:

- hourly sulfur dioxide levels on occasion could have been elevated for most of the day (Figure 21),
- hourly sulfur dioxide levels on occasion could have been as high as 800 ppb (Figures 20 and 21), and
- hourly sulfur dioxide levels on occasion could have been elevated off-and-on for several days in a row (Figure 20).

Table 40 in Appendix B is a summary of the harmful effects from brief exposures to sulfur dioxide. Data in Table 40 show that people who lived in the areas listed previously that are within 1,540 feet of the kiln might have experienced the following harmful effects:

- an increase in airway resistance and bronchoconstriction,¹⁷
- wheezing and shortness of breath,
- an increase in heart rate and breathing rate,
- cough, and
- throat irritation.

Persons most likely to have experienced these symptoms first were those people with asthma who were exercising at the time of exposure to sulfur dioxide; as sulfur dioxide levels rose, persons with asthma who did not exercise as well as persons without asthma would also start to experience symptoms. For instance, at 100 ppb, the only effect that might occur is an increase in airway resistance in exercising asthmatics. As sulfur dioxide levels approached and exceeded 500 ppb, wheezing and shortness of breath might have occurred in some persons with asthma who were exercising during exposure. Exposure at this level may require medication (bronchodilators) to relieve symptoms. Sulfur dioxide levels exceeded 500 ppb at the Ancote Road monitoring station on the following dates:

September 24, 1977	January 13, 1978	February 15, 1978	April 15, 1979
September 28, 1977	January 14, 1978	April 7, 1978	April 16, 1979
September 29, 1977	January 18, 1978	April 9, 1978	April 17, 1979
October 15, 1977	February 6, 1978	September 7, 1978	April 18, 1979
December 18, 1977	February 14, 1978	October 6, 1978	April 19, 1979

Sulfur dioxide levels exceeded 500 ppb and at least 1 hour exceeded 800 ppb on two dates: December 18, 1977 (8 hours over 500 ppb), and April 18, 1979 (5 hours over 500 ppb).

¹⁷ An increase in airway resistance means that air traveling through the airway passages in the lungs is meeting more resistance; It is a precursor to bronchoconstriction, which is the narrowing of the air passages in the lung. If bronchoconstriction is severe, wheezing and difficulty breathing can occur.

It is important to remember that a reported level of 500 ppb or 800 ppb sulfur dioxide is an average sulfur dioxide level over 1 hour. This means that as a plume of sulfur dioxide passed a populated area, there were likely to be periods within that hour when sulfur dioxide levels were higher than the average level and periods when sulfur dioxide levels were lower than the average level. Therefore, for the 1 hour when sulfur dioxide levels were measured at an average concentration of 800 ppb, there might have been intervals within that hour (for example, 10 minutes or 30 minutes) when sulfur dioxide levels were much higher and much lower. Sulfur dioxide levels for brief periods might have been two to three times the average (e.g., 1,600 ppb or 2,400 ppb) (EPA 1986). This is important because Table 40, Appendix B, shows that brief exposures of 10 to 20 minutes to 1,000 to 8,000 ppb sulfur dioxide can cause more serious damage to the lungs. In addition to shortness of breath and wheezing, persons (those with and without asthma) might experience symptoms such as increased heart and breathing rate, throat irritation, redness in the airways, and increased number of inflammatory cells in fluid from the lungs (Amdur et al. 1953; Frank et al. 1962; Sandstrom et al. 1989; Sheppard et al. 1981). Controlled studies in people with asthma have shown that repeated exposures to sulfur dioxide can reduce the lung's responsiveness to sulfur dioxide. For instance, lung response was reduced in 10 exercising persons with asthma who were exposed to 1,000 ppb sulfur dioxide in a chamber during repeated exercise. In another study, bronchoconstriction was less severe in exercising persons with asthma on the second day of a 2-day exposure period, thus implying that some people might develop a tolerance to sulfur dioxide (Kehrl et al. 1987; Linn et al. 1984a). This reduced response has been recognized in workers (Department of Labor 1975); however, this tolerance was not observed in other studies of persons with asthma when tested 1 day and 7 days after the initial exposure to sulfur dioxide (Sheppard et al. 1983).

As mentioned previously, exposure to 100 ppb sulfur dioxide in exercising asthmatics can cause a mild increase in airway resistance. This increase can be detected in a clinical setting but is not likely to cause overt symptoms in exercising asthmatics. Airway resistance returns to normal shortly after exposure to sulfur dioxide ends. When exposures approach 500 ppb in exercising asthmatics, symptoms of wheezing and shortness of breath will occur in some asthmatics. In experiments with some asthmatics, medication was required to relieve these symptoms; therefore, they are not always minor symptoms. When exposures approach 1,000 ppb sulfur dioxide, some healthy people will develop an increase in airway resistance along with an increase in heart rate and breathing rate. A more detailed discussion of the adverse effects of sulfur dioxide can be found in Appendix E and summary of human and animal studies is in Table 40 (Appendix B).

5.2.3.2. Long-Term Exposures to Sulfur Dioxide

Two human studies—the Harvard Six Cities Study (HSCS) (Dockery et al. 1993) and the American Cancer Society (ACS) studies (Pope et al. 1995, 2002)—analyzed the effect of long-term exposure to sulfur dioxide on human health. The ACS study is a nationwide study that compares air pollutant levels to rates of various diseases and death. These findings were initially reported in 1995 (Pope et al. 1995) and updated in March 2002 (Pope et al. 2002). An important finding in the 2002 report is that exposure to sulfur dioxide over many years is associated with a small increase in the number of deaths. This increase in the number of deaths was found when

looking at people who died from all causes of death, when people died from heart or lung disease, and when people died from lung cancer. The 2002 report found that exposure to ozone, nitrogen dioxide, and carbon monoxide did not increase the number of deaths at the average levels reported in the cities studied. The increase in death rate in this study could be detected because about 500,000 people participated in the study, which allowed the scientists to detect very small increases in the effect of sulfur dioxide exposure.

The ACS study measured sulfur dioxide levels across the United States as part of the study. In 1980, the 24-hour average sulfur dioxide level was 9.7 ppb in 118 U.S. cities. The 24-hour average sulfur dioxide level in 126 cities from 1982 to 1998 decreased to 6.7 ppb.

The results of the 2002 ACS study (Pope et al. 2002) are supported by the 1995 ACS study (Pope et al. 1995) and the HSCS (Dockery et al. 1993). The Health Effects Institute (HEI) re-analyzed the HSCS and the 1995 ACS study results and found that exposure to sulfur dioxide was associated with an increase in the number of deaths (Krewski et al. 2000).

Table 44 in Appendix B shows the annual average sulfur dioxide levels from 1977 to 1981 (the years Stauffer operated) and 1982. Samples were collected from the Anclothe Road monitoring station, and the annual average is based on the 24-hour sulfur dioxide levels measured throughout the year. Annual average sulfur dioxide levels ranged from about 17 ppb in 1977 to 4 ppb in 1981. These sulfur dioxide levels are similar to the levels reported in the ACS study (Pope et al. 2002) that was associated with a small increase in the number of deaths from heart and lung disease. It should be noted that these annual sulfur dioxide levels reflect exposure levels that existed at the Anclothe Road monitoring station. When deciding whether people who lived farther away from the Stauffer facility might have been at risk, the following factors are important to remember:

- People who lived or worked within 1,540 feet of the kiln before 1982 in the direction of the Anclothe Road monitoring station were the only people who were exposed to these levels of sulfur dioxide,
- People who lived or worked within 1,540 feet of the kiln between 1947 and 1981 had the potential for the longest period of exposure to sulfur dioxide and are likely to be at greatest risk,
- People who lived or worked more than 1,540 feet from the kiln before 1982 were probably exposed yearly to lower levels of sulfur dioxide, and
- The farther someone lived or worked from the kiln before 1982, the lower that person's yearly exposure to sulfur dioxide was likely to have been.

Caution is warranted in trying to make firm conclusions about people's risk for harmful effects from sulfur dioxide emissions from Stauffer. Except for sulfur dioxide levels measured at the Anclothe Road monitoring station, it is not known precisely what levels of sulfur dioxide people were exposed to (a) who lived in other directions from Stauffer, (b) who lived at other distances from Stauffer, and (c) who lived near Stauffer between 1947 and 1976, the years for which air monitoring data are not available.

However, air modeling of sulfur dioxide levels shows that residents who lived near the Stauffer facility might have been exposed to annual sulfur dioxide levels that were similar to the annual levels measured at the Anclote Road monitoring station.

5.2.4. Results From Modeling Past Exposures

5.2.4.1. Brief Exposures to Sulfur Dioxide

ATSDR used an air dispersion model to predict sulfur dioxide levels at more than 4,000 locations surrounding the Stauffer facility. The basis for the air dispersion model is described in the Air Contamination subsection of the Environmental Contaminants and Other Hazards section. Figure 19 in Appendix A shows 12 of the locations where the model predicted sulfur dioxide levels; Table 45, Appendix B, describes these locations. The maximum hourly sulfur dioxide level measured at the Anclote Road monitoring station served as the basis for predicting the maximum hourly sulfur dioxide levels at other locations near the Stauffer facility (1) when wind was blowing in that direction and (2) when Stauffer had a release of sulfur dioxide similar to the release that caused the maximum level to be detected at the Anclote Road monitoring station. Therefore, over the 5 years that data are available, the model predicts the highest hourly sulfur dioxide level that might exist at some other location in Tarpon Springs and surrounding areas. It is of particular interest to note that the model predicts that the highest hourly sulfur dioxide level at Gulfside Elementary School was about 1,000 ppb.

The air dispersion model was also used to generate contour maps showing the model's estimate of the extent of hourly sulfur dioxide levels. Based on the model, Figure 26 shows the extent of sulfur dioxide migration using three levels as marker: 840 ppb, 500 ppb, and 100. The maximum hourly level of 840 ppb is the highest level measured at the Anclote Road monitoring station, and the map shows the extent of that concentration in every direction from the kiln. Similarly, the map shows the extent in every direction for 500 ppb sulfur dioxide, the level at which wheezing and shortness of breath has been observed in exercising asthmatics. Figure 26 also shows the extent of migration using 100 ppb sulfur dioxide, the level at which an increase in airway resistance has been observed in exercising asthmatics.

In conclusion, residents of Tarpon Springs, Holiday Estates, and surrounding areas were probably exposed on occasion to sulfur dioxide levels that might have caused the following harmful effects:

- an increase in airway resistance and bronchoconstriction,¹⁸
- wheezing and shortness of breath,
- an increase in heart rate and breathing rate,
- cough, and
- throat irritation.

¹⁸ An increase in airway resistance means that air traveling through the airway passages in the lungs is meeting more resistance; bronchoconstriction is the narrowing of the air passages in the lung.

Persons most likely to have experienced these symptoms first were those with people with asthma who were exercising at the time of exposure to sulfur dioxide; as sulfur dioxide levels rose, persons with asthma who did not exercise as well as persons without asthma would also start to experience symptoms. For instance, at 100 ppb, the only effect that might occur is an increase in airway resistance in exercising asthmatics. As sulfur dioxide levels approached and exceeded 500 ppb, wheezing and shortness of breath might have occurred in some persons with asthma who were exercising during exposure. Exposure at this level may require medication (bronchodilators) to relieve symptoms.

As described previously, there are likely to be periods shorter than an hour when sulfur dioxide levels were higher than the average hourly level and periods when sulfur dioxide levels were lower than the average hourly level. Therefore, for the 1 hour when sulfur dioxide levels were measured at an average concentration of 791 ppb, there might have been intervals within that hour (for example, 10 minutes or 30 minutes) when sulfur dioxide levels were much higher and much lower. Sulfur dioxide levels for brief periods might have been two to three times the average (e.g., 1,600 ppb or 2,400 ppb), if not more. This is important because Table 40 in Appendix B shows that brief periods of exposure of 10 to 20 minutes to 1,000 to 8,000 ppb sulfur dioxide can cause more serious damage to the lungs. In addition to shortness of breath and wheezing, persons with and without asthma might experience symptoms such as increased heart rate and breathing, throat irritation, red/irritated airways, and cellular damage to the lungs. Also, it is reasonable to assume exposure to sulfur dioxide over many hours or off-and-on for many days might have increased the possibility of harmful effects because of the extended exposure period.

5.2.4.2. Long-Term Exposure to Sulfur Dioxide

Annual sulfur dioxide levels were elevated at the Anclote Road monitoring station when the Stauffer facility was operating (Table 44 in Appendix B) and dropped in 1982, the year the facility no longer produced phosphorus. Using results for the dispersion model, it is possible to predict annual sulfur dioxide levels at the same locations around Tarpon Springs and Holiday Estates (see Table 46, Appendix B). The air dispersion model was also used to generate a contour map that shows the extent of yearly sulfur dioxide levels in the Tarpon Springs area (see Figure 27). Table 46 shows that locations 4, 5, and 7 have significantly higher annual average sulfur dioxide levels compared with the Anclote Road monitoring station, whereas locations 2, 9, and 10 are similar the Anclote station. Location 5 are businesses due east of the Stauffer facility and locations 4 and 7 are residential areas west and southwest of the facility, respectively. It should be noted that the estimated annual average sulfur dioxide levels at Gulfside Elementary School are similar to the levels at the Anclote Road monitoring station. In general, when the Stauffer facility was operating, the air model predicts that residents in Tarpon Springs, Holiday Estates, and the surrounding area were likely to have been exposed on a long-term basis to elevated levels of sulfur dioxide in air based on annual averages. Annual air levels of sulfur dioxide were significantly reduced after the Stauffer facility closed.

The effect of long-term exposure to sulfur dioxide has been reported in several human studies. These studies include the HSCS (Docker et al. 1993) and the recently updated ACS studies (Pope et al. 2002) as well as a re-analysis of these studies by the Health Effects Institute (Krewski et al. 2000). The Pope study (Pope et al. 2002) showed a small, but measurable, increase in the relative risk for cardiopulmonary (heart and lung) mortality from exposure to yearly average sulfur dioxide levels of 6.7 to 9.7 ppb.

The predicted annual average sulfur dioxide levels reported in Table 46 when the Stauffer facility was operating are similar to the levels reported in the ACS and HSCS studies at which the authors showed an increase in cardiopulmonary mortality (Docker et al. 1993, Pope et al. 2002). Since the Stauffer facility operated for several decades, it is reasonable to assume that residents in Tarpon Springs and Holiday Estates could have been exposed to elevated levels of sulfur dioxide for that period if their industrial processes were similar. Since these annual sulfur dioxide levels are estimated based on an air dispersion model, some uncertainty exists in the accuracy of the predicted levels thus adding some uncertainty to the conclusions about possible health effects.

5.2.5. Demographic Information for Past Exposures

Figure 25 in Appendix A uses 1980 census information to show estimated demographic information about persons who lived within a 1-mile radius of the Stauffer facility just before the facility closed. Almost 6,000 persons lived within 1 mile of the Stauffer facility before it closed; 240 were children 6 years of age and younger and about 2,300 were persons older than 65 years of age.

5.2.6. Current Sulfur Dioxide Exposures

From 1982 to 1996, yearly average sulfur dioxide levels were about 1 or 2 ppb at the Anclote Road monitoring station. These sulfur dioxide levels are well below the yearly average levels in 17 ppb and 14 ppb in 1977 and 1978, respectively, when Stauffer was operating. Yearly sulfur dioxide levels of 1 to 2 ppb are below the levels that cause harmful effects from long-term exposure over many years.

5.3. Exposure to Particulate Matter in Air and the Possibility of Harmful Effects

ATSDR identified particulate matter for further evaluation in this public health assessment because air data are available for TSP at the Anclote Road monitoring station during the period when the Stauffer facility was operating, 1977 to 1981. TSP data are also available from after the facility closed until 1989, when the Anclote Road monitoring station stopped collecting air samples.

Particulate matter is ubiquitous both in the outdoor and indoor environments. Besides the outdoor sources of PM exposures to the community (including the Stauffer facility), there are numerous

other indoor sources of PM exposures from cooking, cleaning, and other indoor activities (EPA 2002c). More-detailed definitions for TSP, PM₁₀, and PM_{2.5} are in Appendix F.

Before 1987, EPA regulated particulate matter in air by measuring TSP levels. TSPs are small particles of matter suspended in air, a large portion of which persons can breathe into their nasal passages and into their lungs. By 1987, a growing amount of research had shown that the air particles of greatest health concern were actually those termed PM₁₀. At the time, PM₁₀ was shown to be capable of penetrating into sensitive regions of the respiratory tract. Consequently, EPA and the states took action in 1987 to monitor and regulate outdoor levels of PM₁₀. Since 1987, hundreds of additional studies (mostly human epidemiologic studies) have been published on the health effects of particulate matter, particularly PM₁₀. These studies generally suggest that adverse health effects in children and other sensitive populations were associated with exposure to particle levels well below that allowed by EPA's PM₁₀ standard at the time (EPA 1997). Moreover, it is generally believed that fine particles (PM_{2.5}) can penetrate into the lungs more deeply than can PM₁₀ and that fine particles are more likely to contribute to adverse health effects than are particles larger than PM_{2.5}.

It is important to note some scientific debate is occurring about the levels of PM_{2.5} or PM₁₀ considered protective for all segments of the population. Threshold concentrations for PM_{2.5} or PM₁₀ (i.e., levels below which no adverse health effects are likely) have not been established from the scientific literature. Therefore, the following evaluation of the public health implications of exposures to particulate matter incorporates the understanding that no established levels exist below which particulate matter will not cause harmful effects.

5.3.1. Background Information About Health Effects From Exposures to Particulate Matter

Over the past 20 years, numerous investigators have researched the public health implications of inhalation exposures to particulate matter. The following discussion reviews this large volume of research, which provided a basis for much of the evaluation presented later in this section.

According to studies on particulate matter, many health effects were associated with PM_{2.5} exposures or with PM_{2.5} exposures coupled with exposures to other pollutants (EPA 1997). A partial list of these health effects follows:

- premature death;
- respiratory-related hospital admissions and emergency room visits;
- aggravated asthma;
- acute respiratory symptoms, including aggravated coughing and difficult or painful breathing;
- chronic bronchitis; and
- decreased lung function that can be experienced as shortness of breath.

These studies indicate that the elderly; children; and persons with pre-existing diseases such as diabetes, respiratory disease and cardiovascular disease are considered to be the most susceptible

to effects of exposure to PM (EPA 2002c). Others are susceptible to less-serious health effects such as transient increases in respiratory symptoms, decreased lung function, or other physiologic changes. Chronic exposure studies suggest relatively broad susceptibility to cumulative effects of long-term repeated exposure to fine particulate pollution, resulting in substantive estimates of population loss of life expectancy in highly polluted environments (Pope 2000). It is important to note that susceptibility is dependent on a number of other important exposure factors, including duration of exposure. The degree to which an added particle burden might impact an individual will likely be affected by that person's age, health status, medication usage, and overall susceptibility to particulate matter inhalation exposures. One factor that might promote increased risk in the older population is that, over their life spans, they might have had more exposure and hence more opportunity to accumulate particles or damage their lungs (EPA 1996). Current epidemiologic research does not provide conclusive evidence of an association between exposure to particulate matter, in general, and cancer. However, because particulate matter is made up of various constituents, depending on the source(s), chemicals that are potential carcinogens are likely to be included in particulate matter.

EPA proposed revisions to its particulate matter standards in 1997 to include a primary (health-based) annual average $PM_{2.5}$ standard of $15 \mu g/m^3$ and a 24-hour $PM_{2.5}$ standard of $65 \mu g/m^3$ (EPA 1997). EPA's scientific review concluded that fine particles are a better surrogate for those components of particulate matter most likely linked to mortality (death) and morbidity (disease) effects at levels below the previous standard. Moreover, fine particles and high concentrations of coarse fraction particles are linked to effects such as aggravation of asthma (EPA 1997, 2002c).

The body of scientific knowledge used to set the health-based $PM_{2.5}$ standard consisted primarily of epidemiologic studies of communities exposed to elevated levels of particulate matter. These epidemiologic studies found consistent associations between exposure and adverse health effects both for (a) short-term or acute particulate matter exposure scenarios (i.e., usually measured in days) and (b) long-term or chronic exposure scenarios (i.e., usually measured in years) (EPA 1996, 2002c). Chronic exposures are best measured using *annual average* $PM_{2.5}$ levels (concentrations above $15 \mu g/m^3$) for one or several years. Acute exposures are best measured by using the *24-hour average* PM_{10} and $PM_{2.5}$ levels (concentration above $150 \mu g/m^3$ and $65 \mu g/m^3$, respectively). For acute exposures related to the Stauffer facility, 24-hour PM_{10} and $PM_{2.5}$ data are not available and, for any given day, it would be difficult to provide a justifiable estimate of these values. Therefore, TSP values will be used to evaluate short-term past exposures to the community. The previous EPA standards for annual average and 24-hour TSP were $75 \mu g/m^3$ and $260 \mu g/m^3$, respectively. Epidemiologic studies indicate increased health risks associated with particulate matter exposures, either alone or in combination with other air pollutants. Moreover, although particulate matter-related increases in individual health risks are small, they are likely significant from an overall public health perspective because of the many persons in susceptible risk groups that are exposed to ambient particulate matter (EPA 1996).

Although the epidemiologic data provide support for the associations mentioned above, an understanding of the underlying biological mechanisms of exposures to particulate matter has not

yet emerged (EPA 1996, 2002c). Much of the toxicological findings related to particulate matter are derived from controlled exposure studies in humans and laboratory animals. However, to date, toxicologic studies on PM have provided important, but limited, evidence for specific PM attributes (constituents) being primarily or essentially responsible for the cardiopulmonary effects linked to ambient PM from epidemiological studies. In most cases, however, exposure concentrations in laboratory studies have been inordinately high as compared to the exposures at which epidemiological studies have found effects (EPA 2002c).

These toxicological studies have focused on acidic aerosols (a subclass of particulate matter), namely sulfuric acid aerosols, particle size, inorganic constituents (e.g., various sulfates and nitrates), metals (e.g., transition metals), organic constituents, diesel exhaust particles, and bioaerosols (EPA 2002c). Epidemiological studies have also investigated PM from various sources (e.g., motor vehicles, fuel oil, industrial, etc) to determine if exposure to different types of PM indicate a stronger or weaker association with adverse cardiopulmonary health effects. All of these studies indicated that soil or crustal sources of PM were not associated with adverse health effects, as measured by mortality. This suggests that the components of natural soil may have minimal toxicity unless contaminated by anthropogenic (man-made) or other sources, such as transition metals (EPA 2002c). From ATSDR's work at another phosphate processing plant in Idado, it was determined that emissions from that plant contained many metals including transition metals (ATSDR 2001b). Although it is likely that there are metals in the Stauffer PM emissions, ATSDR does not have specific information regarding the type and concentrations of these metals. Moreover, ATSDR does not have information that phosphate processing plants, in general, emit PM with any greater or lesser toxicity than other combustion sources of PM that have shown an association with adverse cardiopulmonary health effects in the numerous epidemiological studies in the literature.

Human exposure studies of particles other than acid aerosols generally provide insufficient data to draw conclusions regarding health effects (EPA 1996). A recent study (Godleski et al. 2000) found that concentrated airborne particles had adverse effects on the electrical regulation of the heart in dogs with a preexisting heart condition, while the impact on normal dogs was not clear. Moreover, biological evidence indicates (Schwartz 1999) that urban combustion particles can

- penetrate past the primary defense mechanisms of the lung,
- elicit inflammatory changes in the lung and systemically (throughout the body),
- contain constituents (for example, soluble transition metals) that by themselves can be demonstrated to produce lung damage,
- produce electrocardiogram changes including arrhythmia (heart irregularities), and
- kill animals with preexisting heart and lung disease.

Human studies also reported inflammatory changes, including systemic changes and changes to cardiovascular risk factors (Schwarz 1999). A brief summary of some of the epidemiologic and controlled human exposure studies of specific physiologic end points is shown in Table 47, Appendix B. It is important to note that the studies shown in Table 47 are only a sampling of some of the studies that have provided clues into the potential biological mechanism linking PM

exposures with adverse health effects, as seen in epidemiological studies. Overall, the human physiologic, toxicological, and other studies have shown changes in either blood plasma viscosity, heart rate, heart rate variability or HRV (HRV refers to the “beat-to-beat” changes in heart rate in relation to changes in physical activity—aging, diseases, and other factors can also effect it), and pulmonary inflammation in relation to particulate matter exposures. In general, it is speculated that interactions among inflammation, abnormal hemostatic function, and altered cardiac rhythm might play an important role in the pathogenesis of cardiopulmonary diseases related to air pollution (particulate matter). An adequate understanding of these relationships is limited and requires further research (Pope 2000). Moreover, although scientific evidence has provided some clues into the biological mechanisms of how particulate matter might elicit adverse health effects in animals and humans, the results of these studies are limited and not always consistent. Therefore, clear evidence of the exact mechanisms has not emerged.

In summary, the epidemiologic evidence strongly suggests that ambient particulate matter exposure is associated with adverse human health effects in many geographic locations in the U.S. (EPA 2002c). However, a great deal of uncertainty remains about many issues related to the overall scientific inquiry into the health effects of particulate matter (EPA 1996, 2002c). For example, some scientists believe that the association found in the epidemiological studies does not provide conclusive evidence that exposure to ambient PM levels actually causes adverse cardiopulmonary health effects because a clear biological mechanism, among other things, has yet to be clearly established. Moreover, several viewpoints exist on how best to interpret the epidemiologic data (EPA 1996, 2002c); for example:

- using particulate matter exposure indicators as surrogate measures of complex ambient air pollution mixtures and using reported particulate matter-related effects to represent those of the overall mixture;
- attributing reported particulate matter-related effects to particulate matter components (per se) of the air pollution mixture, therefore, they reflect independent particulate matter effects; and
- viewing particulate matter both as a surrogate indicator as well as a specific cause of health effects.

Although there are some indications that PM effects vary depending on geographic location and source (EPA 2002c), in general, reduction of particulate matter exposure would be expected to lead to reductions in the frequency and severity of particulate matter-associated health effects (EPA 1996).

5.3.2. TSP, PM₁₀ and PM_{2.5} Exposures Near Stauffer

As previously indicated, during the years Stauffer operated, ambient air monitoring for particulate matter measured concentrations of only TSP. The statistically significant decrease in particulate matter levels at the Anclote Road monitoring station after Stauffer ceased its operations clearly tells us that the facility’s emissions contributed to particulate matter exposures at off-site locations. Unfortunately, the available sampling data do not indicate the relative amounts of PM₁₀

and PM_{2.5} within the TSP, because the air samples were never analyzed using appropriate methods for their particle size distribution. It is important to have estimates of PM₁₀ and PM_{2.5} levels, because exposures to these size fractions are far better indicators of adverse health effects than is exposure to TSP.

ATSDR investigated two options for estimating PM_{2.5} exposures that resulted from Stauffer's emissions in order to evaluate the public health implications of particulate exposures. Through these options, we have estimated the past exposure levels of PM_{2.5} resulting from Stauffer's emissions. We emphasize that these estimates are based on our understanding of particulate emissions from elemental phosphorus production facilities, and they are not based on actual air quality measurements from the Stauffer area. As a result, there is some uncertainty associated with these estimates, as we acknowledge throughout this section and in our conclusions. However, we note that the two approaches we took to estimate PM_{2.5} exposures resulted in very similar answers, thus giving us some confidence that we have made reasonable estimates of actual exposures. Our two estimation approaches are described below, followed by a summary of our findings:

- ▶ *Modeling analysis.* As Section 3.3.3.3.2 describes, we used a dispersion modeling analysis to predict how Stauffer's stack emissions affect off-site concentrations of particulate matter. Our modeling analysis found that the stack emissions likely contributed 4 µg/m³ to annual average PM_{2.5} levels at the Anclothe Road monitoring station.

We have two reasons to believe that this value understates Stauffer's actual air quality impacts. First, this analysis does not consider the impacts of fugitive emissions on air quality, because fugitive emissions from Stauffer were never characterized. Although fugitive emissions typically occur in larger particle size fractions, fugitives from furnace tapping probably were predominantly fine particles. Second, our modeling does not account for secondary formation of aerosols. This is an important consideration for elemental phosphorus production facilities, which are known to emit significant quantities of aerosol precursors (e.g., sulfur dioxide, phosphorus pentoxide). For these reasons, our modeling predictions likely understate the PM_{2.5} air quality impacts at off-site locations.

- ▶ *Analysis of ambient air monitoring data.* Given the shortcomings of the modeling analysis, ATSDR used information on particle size distributions from areas near other elemental phosphorus production facilities to estimate the PM_{2.5} levels at the Anclothe Road monitoring station. Specifically, extensive air sampling data have been collected near the fence-line of an elemental phosphorus production facility in southeastern Idaho. These data suggest that the average ratio of PM₁₀ to TSP concentrations was 0.5 (with a standard deviation of 0.14) (ATSDR 2001b). Similarly, the average ratio of PM_{2.5} to PM₁₀ concentrations in the immediate vicinity of this facility was 0.6. ATSDR notes that ratios could also be derived from sampling data collected in Florida after Stauffer closed; however, we decided that particle size distribution data in the vicinity

of an active elemental phosphorus production facility is likely more representative of conditions near Stauffer before 1981.

For an *estimate* of the PM_{2.5} levels near Stauffer, ATSDR applied the particle size ratios in the previous paragraph to the measured TSP concentrations at the Anclothe Road monitoring station. These calculations, which are shown in Tables 48 and 49 of Appendix B, suggest that annual average PM_{2.5} levels at the Anclothe Road monitoring station were likely between 18 and 22 µg/m³. Our calculations also suggest (see Appendix G) that air emissions from Stauffer may have accounted for approximately 7 µg/m³ of PM_{2.5} at the Anclothe Road monitoring station while the facility operated.

ATSDR acknowledges that there is considerable uncertainty applying the particle size factors from another facility to the data collected near Stauffer. Though we clearly understand that the magnitude of particulate pollution is expected to differ between the two facilities (since production levels at the Idaho facility were far greater than those at Stauffer), there is reason to believe that the particle size distribution would not vary dramatically between these sites, which used similar production processes.

These analyses actually provide a somewhat consistent account of estimated PM_{2.5} levels. Our modeling, which we have reason to believe understated fine particulate impacts, suggests that Stauffer's air emissions contributed 4 µg/m³ to annual average PM_{2.5} concentrations at the Anclothe Road monitoring station. Our review of monitoring data, on the other hand, suggests that Stauffer's contribution to PM_{2.5} levels might have been 7 µg/m³. The fact that these estimates, which were generated from two entirely different data sets, are so similar gives some reassurance that the estimated PM_{2.5} levels do not grossly misrepresent Stauffer's past air quality impacts.

In summary, the collective weight of evidence suggests that Stauffer's air emissions definitely impacted local air quality. We are confident in stating that these emissions likely contributed as much as 32% of the TSP measured at the Anclothe Road monitoring station, but insufficient data are available to make similar definitive statements about the particle size distribution of Stauffer's facility-wide emissions. Our best estimate is that Stauffer's air emissions contributed 7 µg/m³ to annual average PM_{2.5} levels at the Anclothe Road monitoring station. We selected this value, instead of our modeling result, because we have reason to believe that the modeling underestimated Stauffer's contribution to PM_{2.5} levels. ATSDR emphasizes that our estimate of Stauffer's contribution to PM_{2.5} levels involves some uncertainty, and the actual contribution to PM_{2.5} levels might be lower or higher than the estimate we use in the PHA. This uncertainty is noted throughout our analyses, and in our conclusions.

The sampling data quite clearly demonstrate that air emissions from Stauffer caused increases in particulate matter concentrations near the facility. However, the particulate matter levels measured near Stauffer between 1977-1981, though greater than Florida's previous air quality standards, were not unusually higher than particulate matter levels routinely measured in many suburban and urban settings throughout the state. When ATSDR evaluates exposure to environmental

contamination, our primary role is to examine whether exposures are at levels associated with adverse health effects. Whether or not other populations experienced greater or lesser exposures does not factor into our public health evaluations for a given site.

Some of the health concerns expressed by community members in relation to past air exposures related to the Stauffer facility (i.e., asthma, breathing problems, chronic obstructive pulmonary disease [COPD], and other nonspecific lung diseases) are reasonably consistent, with adverse health outcomes reported in the epidemiologic literature for both acute and chronic exposures to particulate matter (or sulfur dioxide). For asthma, it is important to note that the scientific literature does not currently suggest that PM causes asthma but that it may exacerbate it. Moreover, as previously indicated, there are other known and suspected factors that may trigger asthma. The consistency between the community's health concerns and the epidemiologic studies does not suggest that a specific person's disease was caused by inhalation exposures to particulate matter. Rather, the cause of any disease is usually a result of multiple factors. For example, smoking is a strong risk factor for many lung and heart diseases. Therefore, smokers make up another population group likely at increased risk for particulate matter-related health effects (EPA 1996). ATSDR has not determined that any of these reported illnesses are elevated in the community in relation to exposures from Stauffer, but only that they are consistent with the findings from the scientific literature.

The following discussion first evaluates the increased risks from exposures to $PM_{2.5}$ (estimated annual averages) on the basis of results from long-term epidemiologic studies, then evaluates the increased risks from exposures to TSP (24-hour maximum values) on the basis of results from acute epidemiologic studies. The ambient air concentrations of particulate matter reported in these epidemiologic studies are compared to estimated and measured levels of particulate matter in the area of the Stauffer facility. The discussions present a qualitative evaluation of the air data collected near the Stauffer facility and should provide context for understanding the possibility of harmful effects to persons exposed to particulate matter who lived near the facility.

5.3.3. Chronic Exposures to Estimated Annual Average $PM_{2.5}$ Levels

Three large cohort studies—HSCS (Dockery et al. 1993) and the two ACS studies (Pope et al. 1995, 2002)—found an association between excess mortality in adults and increasing $PM_{2.5}$ concentrations in various cities and metropolitan areas of the United States. More specifically, HSCS showed a 31% increase in mortality for every $25 \mu\text{g}/\text{m}^3$ increase in $PM_{2.5}$, and the first ACS study showed a 17% increase in mortality for every $25 \mu\text{g}/\text{m}^3$ increase in $PM_{2.5}$. The reported ranges of annual average $PM_{2.5}$ for HSCS and the first ACS study were $11\text{--}30 \mu\text{g}/\text{m}^3$ (mean) and $9\text{--}34 \mu\text{g}/\text{m}^3$ (median), respectively, for the least to the highest levels of $PM_{2.5}$ in a given city during the study period. These risks were based on the excess mortality between the least to the most polluted cities (EPA 1996). The second ACS study (Pope et al. 2002) expanded further on the results of the first study by increasing the number of persons in the study, including the effects of gaseous co-pollutants, and controlling for additional factors that might be independent risk factors for cardiopulmonary-related disease. The study looks at exposure to $PM_{2.5}$ for the time

periods 1979–1983, 1999–2000, and the average of all of these years. The results of the study showed that each $10 \mu\text{g}/\text{m}^3$ increase in $\text{PM}_{2.5}$ was associated with, depending on the years of exposure, an approximate 4%–6%, 6%–9%, and 8%–14% increase for all-cause, cardiopulmonary, and lung cancer mortality, respectively (Pope et al. 2002). These percentage risk estimates imply an incremental increase in the mortality rate occurs when comparing long-term exposures to a person residing in a city with lower $\text{PM}_{2.5}$ exposures to a person who lives in a city with higher $\text{PM}_{2.5}$ exposures.

Given the importance of the HSCS and ACS studies, HEI funded a study to re-analyze the results of the HSCS and first ACS studies (Krewski et al. 2000). The first major conclusion of the re-analysis study was that the original results of these two studies was of high quality and that the independent analysis of the data produced essentially the same results as the original studies. Moreover, the study tested the original results against a range of alternative variables and analytic models without substantially altering the original findings of an association between indicators of particulate matter air pollution and mortality. In addition, an association between sulfur dioxide and mortality was observed and persisted when other possible confounding variables were included. The study found relatively stable associations of mortality with fine particles, sulfates, and sulfur dioxide. The final interpretation by the researchers suggested that increased risk of mortality might be attributable to more than one component of the complex mix of ambient air pollutants in urban areas of the United States (Krewski et al. 2000).

The second ACS study (not included in the Krewski et al. [2002] re-analysis) also found an association with all-cause, cardiopulmonary, and lung cancer mortality and sulfur dioxide. No consistent association was found with other gaseous co-pollutants such as ozone, nitrogen dioxide, and carbon monoxide (Pope et al. 2002).

These and other chronic exposure studies, taken together, suggest that increases in mortality in disease categories might occur consistent with long-term exposure to airborne particles and that at least some fraction of these deaths reflect cumulative particulate matter impacts above and beyond those exerted by acute exposures events (EPA 1996). The HSCS and the two ACS studies controlled for subject-specific information about other relevant risk factors (such as cigarette smoking and occupational exposure); thus, these studies appear to provide reliable information about the effects of long-term exposures to particulate matter (EPA 1996; Pope et al. 2002). The findings of an independent re-analysis by HEI of HSCS and the first ACS study strengthen the conclusions of the original studies and show that they were based on sound science. Overall, the weight of epidemiologic data suggests long-term, repeated particulate matter exposure (especially fine particulate matter) has been associated with increased population-based mortality rates as well as a small increased risk of mortality in broad-based cohorts or samples of adults and children.

The epidemiologic evidence, available monitoring data from the Anclothe Road monitoring station between 1977 and 1981, and the estimates of historic levels of $\text{PM}_{2.5}$ during this time frame show

that the community residing in or working in the following areas might have experienced adverse health effects similar to those reported in the literature from chronic exposures to PM_{2.5}:

- The Flaherty Marina (before 1982),
- Residential homes built before 1982 southwest of the Stauffer facility along the shore of the Anclote River,
- Residential homes west of the Stauffer facility built before 1982 and within 1,540 feet of the kiln, and
- Commercial and industrial businesses east of the Stauffer facility along Anclote Road built before 1982 and within 1,540 feet of the kiln.

The estimated average levels of PM_{2.5} during the years 1977 to 1981 (about 18-22 $\mu\text{g}/\text{m}^3$) is similar to the mid to upper exposure levels reported in the HSCS and the two ACS studies. In addition, the estimated increase in average PM_{2.5} levels due to Stauffer emissions during the years 1977–1981 (about 7 $\mu\text{g}/\text{m}^3$) is associated with a measurable increase in adverse cardiopulmonary health outcomes as reported in the HSCS and the two ACS studies. However, to put this into more perspective for the population exposed to long-term levels of PM_{2.5} likely attributable to Stauffer emissions, let us look closer at the findings of the second ACS study. If one considers the U.S. death rate as the background risk, the ASC study can be interpreted in a different way. That is, for every 2,000-4,000 persons exposed to an increase of 10 $\mu\text{g}/\text{m}^3$ PM_{2.5}, one additional death, due to cardiopulmonary disease, may be expected. In addition, for every 14,000 persons exposed, to an increase of 10 $\mu\text{g}/\text{m}^3$ PM_{2.5}, one might expect an additional death due to lung cancer. Many of these deaths from the second ASC study are likely in the most susceptible populations; that is, the elderly and those with pre-existing heart and lung illnesses. Given that the population exposed to PM_{2.5} attributable to Stauffer may have been lower than 2,000 persons, it is unlikely that exposure to Stauffer emissions alone resulted in an excess death. However, it is important to note that for every death attributable to a long-term increase in PM_{2.5} exposure levels from the HSCS and the two ACS studies, there are likely many more cases of individual symptoms of lung and heart diseases and reductions in lung function. Although ATSDR offers the above perspective for the community to better understand their risk of the most serious adverse health effect, we do so with some uncertainty. Given that the exposed population may have had a higher percentage of elderly (a likely sensitive population), ATSDR cannot completely rule-out any of the adverse health effects that have been associated with PM exposures. In any case, the risk of an adverse cardiopulmonary health outcome was likely reduced once the Stauffer facility ceased operation in 1981 because the levels of exposure to fine particulate matter were lowered.

5.3.4. Acute Exposures to 24-Hour Average TSP

Early indications that fine particles are likely important contributors to observed particulate matter-mortality and morbidity (disease) effects came from evaluations of past serious air pollution episodes in Britain and the United States. The more severe episodes were characterized by several days of calm winds, during which large coarse particles rapidly settled out of the atmosphere and concentrations of fine mode particles dramatically increased (EPA 1996). Most of the epidemiologic studies of particulate matter to date focus on acute exposures (usually daily)

and their association with various health end points such as mortality counts, hospitalizations, symptoms, and lung function. Unfortunately, until recently (after publication of the new proposed PM_{2.5} standards), very little daily monitoring of fine particles occurred, and most of the studies used other methods of measuring particulate concentrations, like PM₁₀ and TSP (Pope 2000). Table 50 in Appendix B provides a summary of the epidemiologic evidence of health effects of acute exposure to particulate matter (Pope 2000).

The results of a major U.S. study that evaluated the association of short-term exposures to PM₁₀ and other pollutants, as related to mortality and morbidity (as measured by hospitalizations), were released in 2000 (Samet et al. 2000). HEI's National Morbidity, Mortality, and Air Pollution Study (NMMAPS) used several new and innovative approaches to overcome some of the limitations of previous studies of daily exposures to air pollutants and their relationship to death and hospitalizations. The approach used was to characterize the effects of PM₁₀ alone or in combination with gaseous air pollutants in a consistent way, in a large number of cities, using the same statistical approach. The study looked at the effects of PM₁₀ and other pollutants on mortality in up to 90 of the largest U.S. cities. In addition, the study looked at morbidity, as measured by daily PM₁₀ effects on hospitalization among those 65 years of age and older, in 14 U.S. cities. HEI concluded that the study made substantial contributions in addressing major limitations of previous studies. The results of the mortality studies were generally consistent with an average approximate 0.5% increase in overall mortality for every 10 $\mu\text{g}/\text{m}^3$ increase in PM₁₀ measured the day before death. This effect was slightly higher for deaths due to heart and lung disease than for total deaths. The PM₁₀ effect on mortality also did not appear to be affected by other pollutants in the model. The 14-city hospital admission study of persons 65 years or older showed a consistent approximate 1% increase in admissions for cardiovascular diseases and about a 2% increase in admissions for pneumonia and COPD for each 10 $\mu\text{g}/\text{m}^3$ increase in PM₁₀ (Samet et al. 2000). The results of the NMMAPS study have been brought into question because of an apparent issue with the software used to estimate the risks associated with exposure to air pollutants. Dominici, F., et al. 2002 re-evaluated the NMMAPS mortality results and has determined that the results are still positive, but it is likely that the actual risk originally calculated will be lowered by about one-half. The re-analysis of the hospital admissions portion of the study is still on-going. In other studies of hospital admissions and visits, a 50 $\mu\text{g}/\text{m}^3$ increase in PM₁₀, resulted in a 3-25% increase in admission and visits for cardiopulmonary diseases (EPA 2002c).

Overall, the particulate matter risk estimates from total mortality epidemiologic studies suggest that an increase of 10 $\mu\text{g}/\text{m}^3$ in the 24-hour average PM₁₀ level (or an increase of 5–6 $\mu\text{g}/\text{m}^3$ in PM_{2.5}) is associated with increased risks of adverse health effects of 0.5%–1.5% (Pope 2000), with even higher risks possible for elderly subpopulations and for those persons with preexisting respiratory conditions (EPA 1996). Although data are not available to determine the levels of short-term PM₁₀ exposures attributable to the Stauffer facility, it is likely that the facility did contribute to increased PM₁₀ exposures to persons living near the Stauffer facility. That is, on any given day, it would be difficult to provide a precise estimate using available TSP data of what the PM₁₀ levels would have been. However, over the long term, about 50% of the TSP measurement

is PM_{10} . Therefore, it is reasonable to assume that on some days PM_{10} levels were appreciably elevated due to Stauffer emissions. These increases in short-term PM_{10} levels would likely result in an increased risk for adverse cardiopulmonary health outcomes listed in Table 50 (Appendix B) for those exposed (especially the elderly and those persons with preexisting heart and lung illnesses).

TSP is not the best measure of particulate matter that is likely to reach the deeper parts of the lung and result in an adverse cardiopulmonary health outcome. However, several studies, predominantly in the 1980s and 1990s, evaluated TSP exposures in relation to deaths and other health outcomes like hospital admissions. Although the results are mixed, the analyses generally showed a 1% to 5% increase in total deaths for every $100 \mu g/m^3$ increase in TSP. Moreover, for total respiratory or COPD hospital admissions in the elderly (aged 65+ years), an approximate 10%–50% increase occurred for every $100 \mu g/m^3$ increase in TSP (EPA 1996; Schwartz 1995).

The results of these epidemiologic studies suggest that the maximum 24-hour levels of TSP measured at the Anclothe monitoring station during the years 1977–1981 exceeded concentrations, on several occasions, that are associated with adverse respiratory health effects. According to the epidemiologic literature, some of the adverse health effects associated with the range of maximum 24-hour TSP levels are increased total acute mortality, increased hospital admissions for the elderly (aged 65+ years) for lung disease, including COPD (EPA 1996). The greatest concern for adverse health effects for short-term exposures to the higher levels of TSP would be the elderly and those persons with preexisting heart and lung illnesses. Moreover, as indicated above in the evaluation of $PM_{2.5}$ exposures, the population exposed to Stauffer emissions was relatively small; therefore, it is unlikely that the most severe health outcome (death) would occur in the population exposed to levels of PM associated with Stauffer emissions. It is far more likely that persons exposed in the susceptible populations would experience lung and heart symptoms and reduced lung function that may lead to a doctor's visit, emergency room visit, or hospitalization.

5.3.5. Acid Aerosol Exposures

Several acids, such as sulfuric acid, phosphoric acid, and hydrofluoric acid, were released from the Stauffer phosphorus processing plant. In addition, phosphorous pentoxide (a signature constituent of phosphorus-processing emissions) and sulfur dioxide can be transformed in the atmosphere into phosphoric acid and sulfuric acid, respectively. All of these acids are considered potential respiratory irritants and could contribute to the overall increased risk of adverse cardiopulmonary health effects.

Studies of past episodes of air pollution suggest that both acute and chronic health effects are associated with inhalation exposures to strongly acidic particulate matter. For example, studies of historical pollution episodes, notably the London Fog episodes of the 1950s and early 1960s, indicate that acute exposures to extremely elevated levels of acid aerosols might be associated with excess human mortality. Studies evaluating present-day U.S. levels of acid aerosols have not found associations between acid aerosols and acute and chronic mortality, but the series of

hydrogen ion (H^+) data used might not have spanned a long enough time to detect H^+ associations. However, several morbidity studies associated H^+ concentrations with increased bronchitis and reduced lung function in children and an increase in respiratory hospital admissions (EPA 1996). Furthermore, animal studies have shown that sulfuric acid aerosols exert their action throughout the respiratory tract, with the site of deposition dependent on the particle size and the response dependent on mass and number concentration of specific deposition sites (EPA 1996). However, animal studies on acid aerosols provide no evidence that ambient acidic particulate matter components contribute to mortality and essentially no quantitative guidance as to ambient acidic particulate matter levels at which mortality would be expected to occur in either healthy or diseased humans. Furthermore, the effects seen in these animal studies were at acid levels that exceed worst-case ambient concentrations by more than an order of magnitude (EPA 1996). There is relatively little new information on the effects of acid aerosols since EPA released its 1996 PM Air Quality Criteria Document (EPA 2002c).

5.3.6 Exposure to Metals and Other Particulates

ATSDR thoroughly reviewed the available air data for particulate matter, sulfur dioxide, phosphorous pentoxide, and fluorides. However, air data for acids, metals, and other pollutants released from Stauffer were not available for review. Current science provides little evidence as to whether the mix of these air contaminants may increase or decrease their toxicological effects because of cumulative exposures. However, the epidemiological evidence does indicate that PM, a measure of a mix of contaminants present in air, including many of the acids and metals that may have been released from Stauffer, is generally a good surrogate measure for estimating the short-term and long-term adverse cardiopulmonary health effects from exposure. From this standpoint, ATSDR evaluated and made definitive public health statements regarding the cumulative health effects of the past exposure to the mix of acid aerosols and particulate metal contaminants, that may have been present in the air around the Stauffer, as measured by PM.

5.3.7. Exposures to Particulate Matter since 1982 and Possible Current Health Effects

As previously indicated, the levels of TSP, PM_{10} and $PM_{2.5}$ were reduced after 1981 when the Stauffer plant stopped operating. The estimated average level of $PM_{2.5}$ at the Anclote Road monitoring station for the period 1982-1989 ($14 \mu g/m^3$) is slightly below the current $PM_{2.5}$ standard of $15 \mu g/m^3$. Like the trend in many areas of the U.S. in the 1990s, $PM_{2.5}$ levels in the Tarpon Springs area were further reduced during those years. Moreover, since 1981, the levels of TSP and PM_{10} in northern Pinellas County have not exceeded any of the respective health-based air quality standards. Since 1981, the estimated and measured levels of PM in the general vicinity of the former Stauffer plant, and subsequent risk of an adverse heart and lung health outcome, were similar to those in many areas of Florida and the U.S.

5.4. Exposure to Fluoride in Air and the Possibility of Harmful Effects

5.4.1. Fluorides

In this discussion, “fluorides” will refer to a group of compounds that include the element fluorine. This includes fluorine gas, hydrogen fluoride (hydrofluoric acid), sodium fluoride, and fluoride complexes such as silicon tetrafluoride. Fluorine is extremely reactive and is unlikely to disperse any distance from its source as fluorine and, therefore, is unlikely to be a concern to the residents around Stauffer. The main fluorides emitted in the production of phosphate fertilizers are hydrogen fluoride, silicon tetrafluoride, and particulates containing fluoride (ATSDR 2001).

5.4.2. ATSDR Ombudsman’s Report

The ATSDR ombudsman’s report (ATSDR 2000a) commented on the need for further evaluation of fluorides. The report also stated that a concerned citizen reported pine trees south of the plant turning brown and that another citizen reported that in 1948 he noticed trees with red leaves that looked burned. In 1948, tests of vegetation near the plant showed high fluorine levels. Unfortunately, specific levels were either unknown or were unstated.

5.4.3. Historical Information About Fluoride Levels in Air

Air sampling has been performed for fluorides a limited number of times on the Stauffer property, off-site while the facility was operating, and when the facility was idle. Two types of data sets exist: (1) data from stack emissions and (2) data collected at remote sampling locations. It is important to realize that both data sets are severely limited in scope and quality to allow accurate predictions of exposure in the community. Estimates of fluoride released into the environment from the Stauffer stack data show that approximately 6 tons per year were released from the facility. This value, however, only includes stack emissions and does not consider other emissions from different parts of the facility. Stauffer processed ore containing approximately 7,000 tons of fluoride per year, and only 6 tons is accounted for as stack emissions, thus leaving the vast majority of fluoride unaccounted. Although most of the “missing” fluoride is likely solid waste, it illustrates the limitations of using just stack data to estimate community exposures and leads to the assumption that fluoride exposures could be underestimated.

Fluoride levels at air sampling stations remote from the stack both on-site and off-site might be more indicative of community exposures. It should be noted, however, that all the data sets collected to date (with the exception of an EPA study conducted in 1987 after the plant was closed (EPA 1987)) suffer from severe data quality issues including the methods used to determine fluoride levels and documentation problems. Following is a summary of sampling dates for fluoride:

- In 1964 and 1976, 10 air sampling stations on-site and in the community sampled fluoride emissions.

- In 1976, sampling was performed at five on-site locations mostly at the north and west perimeters of the site.
- In 1979 and 1981, two on-site locations were sampled.
- In 1987, EPA conducted fluoride testing after the facility closed.

From the limited sampling conducted from 1964 to 1987, one 24-hour air sample was measured at 38.7 ppb, which exceeded ATSDR's acute inhalation MRL of 30 ppb. The remaining air samples were below the acute and intermediate inhalation MRLs. It should be noted that no chronic inhalation MRL exists because no reliable human or animal studies exist.¹⁹ The air sample that exceeded the acute inhalation MRL was collected in 1981 near the southern boundary of the Stauffer facility. No air sample results from off-site areas contained fluoride at levels that exceeded an MRL.

ATSDR's ombudsman report refers to two personal communications where damage to vegetation was noted. It is quite possible for fluoride, especially hydrogen fluoride, to cause the type of damage noted. However, considering the complex nature of the emissions from the Stauffer plant, including high sulfur dioxide levels and the unreliability of the off-site sampling, it would be difficult to conclude that the damage was due to hydrogen fluoride, other acidic pollutants, natural processes, or a combination of all three.

5.4.4. Health Effects

The acute inhalation MRL of 30 ppb is based on the irritant effects of hydrogen fluoride to the nose and lungs. The lowest level that causes irritation in humans after acute (less than 2 weeks) exposure is 120,000 ppb, which causes irritation after a 60-minute exposure period. This LOAEL can be adjusted to a human equivalent exposure level of 34,392 ppb using methods developed by the US EPA (US EPA 1994). The measured level at the Stauffer facility fenceline of 38.7 ppb (measured over 24 hours) is about 900 times lower than the level known to cause harmful effects. Based on this difference, it is unlikely that harmful effects would occur in someone exposed to 38.7 ppb. However, some uncertainty exists in this conclusion because the 38.7 ppb was an average level over 24 hours of sampling and the LOAEL established by the animal study was a 1-hour exposure.

It may be that the 24-hour measurement of 38.7 ppb is masking a plume that migrated from the facility rather quickly. Evidence exists for this assumption from hourly sulfur dioxide measurements, which show that at times a plume of sulfur dioxide will pass an air monitoring station within a few hours or an hour or two. If the fluoride plume passed the air monitoring

¹⁹ATSDR's acute inhalation MRL covers exposure periods up to 2 weeks; ATSDR's intermediate inhalation MRL covers exposure periods from 2 weeks to 1 year; and ATSDR's chronic inhalation MRL covers exposure periods greater than 1 year. When air levels are below the MRL, harmful effects are not likely for that exposure period. Exceeding an MRL, however, means that further toxicological evaluation is necessary to determine whether or not harmful effects might be possible.

station in 60 minutes, fluoride levels in the plume would be about 900 ppb (38.7×24). This level is now about 37 times lower than the human equivalent level of 34,392 ppb that is thought to cause mild irritation to the nose. However, from the environmental data available, it is not possible to actually determine whether or not the 24-hour level of 38.7 ppb might have short periods of high fluoride levels. Added to this uncertainty is the fact that the plume would have to migrate across the river or to some other residential area before residents would be exposed. This migration would further dilute the fluoride levels.

In conclusion, although irritant effects seem unlikely from the one sample that exceeded the acute inhalation MRL of 30 ppb, firm conclusions cannot be drawn because the sample averaged fluorides levels over 24 hours, which might have masked higher levels of fluorides in a migrating plume. In addition, too few air samples were taken for fluorides when the Stauffer facility was operating to determine what levels of fluorides were being released. It is important to remember that extensive samples for fluorides at other phosphate production facilities did not show fluorides to be a public health issue.

5.4.5. Current Exposures

The Stauffer plant is now closed and is no longer producing elemental phosphorus. In 1987, several years after the Stauffer plant ceased operations, EPA conducted an air sampling study (EPA 1987). No fluoride was detected in any of the 12 samples collected for the study. Because conditions at the closed facility have not changed since this study, there is no reason to suspect that fluoride levels have increased.

5.5. Exposure to Ionizing Radiation and the Possibility of Harmful Effects

5.5.1. Introduction

In conducting the evaluation of exposure to ionizing radiation from the Stauffer facility, ATSDR reviewed the scientific literature for radium-226 and ionizing radiation. ATSDR relied on its toxicological profiles for radium and ionizing radiation (ATSDR 1990, 1999b), which summarize pertinent toxicity data from animal and human studies. In addition to the agency's toxicological profiles, ATSDR also used recently published scientific reports and consensus scientific recommendations from the International Committee on Radiation Protection (ICRP), the National Council on Radiation Protection and Measurements (NCRP), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and the National Academy of Sciences reports.

To evaluate exposure from ionizing radiation and radioactive contaminants, ATSDR develops MRLs when sufficient human or animal studies are available. ATSDR's MRL for ionizing

radiation is 100 millirem (mrem) above background.²⁰ ATSDR uses a weight-of-evidence methodology when selecting MRLs.

Exceeding an MRL, however, does not mean that harmful effects will occur. Rather, exceeding an MRL means that a more thorough radiologic evaluation is necessary. Some factors that are considered as part of a more thorough evaluation include the following:

- Compare radiation levels to those that cause harmful effects to determine how close the levels are;
- Determine who is exposed and if those persons are more sensitive to the radiation than others are;
- Evaluate the location of radiation samples in relation to where people live;
- Determine if the radiologic effect in a study is applicable to the people who are exposed;
- Consider different aspects of exposure in the study (e.g. dosing period, amount, frequency of exposure) and its applicability to people who live near the site and their exposure;
- Consider the effect of uncertainty in exposure estimates; and
- Consider the effect of uncertainty in deciding possible harmful effects.

After conducting a site-specific radiologic evaluation, ATSDR describes whether or not people who are exposed to site contaminants might experience harmful effects from that exposure. As part of this discussion, ATSDR also describes the uncertainty that usually exists in making these decisions.

5.5.2. Radiologic Contaminant of Concern

Radium-226 is the only radiologic contaminant of concern at or near the former Stauffer site. Radium-226 levels exceed ATSDR's CVs at both on-site and off-site locations. ATSDR used REDRAD version 6.2 computer code to estimate dose rates to future occupants of the former Stauffer site with a residential scenario and assumed no remediation (Yu et al. 2000). The radium is part of a glasslike slag, even in dust, and is not bioavailable; therefore, the radium toxicity is not important, only exposure to external gamma radiation from radium (ATSDR 1990).

Using the maximum on-site concentration of 1,800 Bq/kg²¹ would correspond to an annual dose of 300 mrem/year above background from direct gamma radiation, plus inadvertent ingestion and inhalation of contaminated dusts. The dose was almost exclusively from EGR, and is three times ATSDR's MRL for ionizing radiation and would be inappropriate for residential development. Even though it is elevated, it would not likely result in any adverse health effects (ATSDR

²⁰A mrem (millirem) is a measure of radioactive dose.

²¹Becquerel per kilogram is equivalent to one radioactive decay per second in a kilogram of material.

1999b); and, to put the radiation dose in perspective, it is less than one-third of the dose a person receives during a diagnostic chest computed axial tomography (CAT) scan (Wall and Hart 1997).

The maximum radium-226 concentration measured at the Gulfside Elementary School was 59 Bq/kg, which, using the same assumptions as above, corresponds to an annual dose of only 10 mrem above background. This dose is 10 times less than ATSDR's MRL of 100 mrem/year above background and does not represent any health threat to any child who attended the school.

The radium concentration on the school grounds does prove that wind-blown dusts did blow to the school from the former Stauffer site. No air monitoring information was available to model air concentrations when the site was in operation. Even though the CV for radium-226 in river sediment was exceeded, no completed exposure pathway existed for river sediments. The public would not receive any dose from the sediments.

5.5.3. Conclusions About Radiation

As the site now exists, it is not suitable for residential use. On-site soil poses a public health hazard should the facility become residential. As expected, radium-226 was the principal radiologic contaminant of concern both on-site and off-site. Surface soil on-site is the most contaminated because of the sheer volume of slag on-site. Of primary concern is that gamma radiation from the slag would result in significantly elevated radiation doses if the land is developed as residential without removing the slag.

The only off-site location with elevated concentrations of radionuclides is the Gulfside Elementary School, which likely received it from wind-borne dust. Directly across the street from the school, trucks were loaded with slag. Off-site concentrations of radionuclides in soil at the school do not pose a health hazard at the levels measured. However, ATSDR was unable to model the air pathway for radioactive exposures because of lack of emissions data from the Stauffer facility.

Radium-226 and its decay products were detected in river sediments upstream and downstream from the site. However, the sediments do not appear to pose any health risk because the contaminant levels are low and the potential for human exposure is minimal.

5.6. Exposures to Contaminants in Private Well Water

Although a few private and commercial wells near Stauffer were tested as early as 1988, most of the 38 private and commercial wells for which data are available were tested between 1999 and 2001. Table 51 in Appendix B summarizes the contaminants and maximum levels found and provides some comments for added insight. Because safety factors are used in setting drinking water standards and comparison values (i.e., screening levels), exceeding one of these values means that a more thorough evaluation is needed to determine whether harmful effects might occur. To determine whether harmful effects might occur, ATSDR does the following:

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- Estimates a dose (the amount someone drinks) for someone who drinks water from a commercial well and from a residential well,
- Compares the estimated dose to health guidelines (usually, ATSDR's chronic MRL).
- Concludes that noncancerous harmful effects are unlikely if the MRL is not exceeded,
- Compares the estimated dose to levels that cause harmful effects if the MRL is exceeded.
- Considers children or sensitive groups in its evaluation.
- Decides whether harmful effects might be possible, and
- Describes the harmful effects that might be expected.

It is important to realize that the previous evaluation covers noncancerous effects. To evaluate the possibility of cancer, ATSDR uses two approaches: a quantitative approach developed by EPA to provide a numerical estimate of cancer risk, and a qualitative weight-of-evidence approach that factors in other scientific information. This weight-of-evidence might include such things as what is known about:

- the chemical's mechanism of action for causing cancer,
- the chemical's metabolism in humans versus metabolism in animals,
- the exposure pattern in human and animal studies versus the exposure pattern at this site,
- the duration of exposure, and
- the chemical's ability to cause cancer in humans versus cancer in animals.

These nonquantitative factors might help to determine whether or not cancer is possible and might help to put the quantitative risk in better perspective.

Studies found that most adults drink less than 8 glasses of water a day, or about 2 liters.²² This estimate includes not only tap water but also beverages, such as soda, citrus drinks, milk, or coffee. Therefore, when ATSDR estimates exposure from drinking, we are assuming that a person gets all of his or her daily fluid intake from tap water. Another step in estimating a person's exposure is to include body weight so the dose looks like this: micrograms chemical per kilogram body weight per day ($\mu\text{g/kg/day}$) or milligrams chemical per kilogram body weight per day (mg/kg/day).

A similar approach is used to determine if children are at risk for harmful effects. In this case, it is possible to estimate the dose for preschool children and school children because they drink about two to four 8-ounce glasses of tapwater every day.

²² A glass of water in this case contains 8 ounces.

5.6.1. Arsenic and the Possibility of Noncancerous Effects

As Table 51 in Appendix B shows, arsenic was found in two commercial wells and one private well at levels that exceed EPA's drinking water standard of 10 ppb. If an adult were to drink, on average, three glasses of water a day from the residential or commercial wells described in Table 51, that person's estimated dose would be below ATSDR's chronic MRL of 0.3 $\mu\text{g/kg/day}$, and he or she would not be at risk for harmful effects. If, however, an adult drank 4 to 8 glasses of water a day from the wells described in Table 51, that person's estimated dose would be between 0.4 $\mu\text{g/kg/day}$ and 0.8 $\mu\text{g/kg/day}$, thus exceeding ATSDR's chronic MRL. To determine whether harmful effects are possible, it is important now to compare the estimated dose in these adults to doses in human studies where harmful effects were observed.

ATSDR's chronic MRL is based on a study of 40,000 Chinese persons in Taiwan who unknowingly used groundwater with arsenic for roughly 45 years (ATSDR 2000b). Because arsenic contamination was so high, people of all ages experienced harmful effects to the skin (specifically small blotches of increased skin pigmentation known as hyperpigmentation and a scaly skin condition known as keratosis), skin cancer, and several types of internal cancer.²³ The typical level of arsenic in drinking water was about 500 ppb, although some wells had a little as 50 ppb and some had more than 1,000 ppb. From this study, ATSDR selected an estimate of the lowest dose that is most likely to result in noncancerous harmful effects. This dose is referred to as the lowest-observed-adverse-effect level (LOAEL). The LOAEL in the Chinese study was 14 $\mu\text{g/kg/day}$. The Chinese study also identified a dose at which no harmful effects were seen. This no-observed-adverse-effect level (NOAEL) was 0.8 $\mu\text{g/kg/day}$ (ATSDR 2000b).

It is now possible to compare the estimated dose of arsenic in people who used the wells described in Table 51 (Appendix B) to the estimated dose of arsenic in the Chinese study that caused harmful effects to the skin.

LOAEL from Chinese study	14.0 $\mu\text{g/kg/day}$
NOAEL from Chinese study	0.8 $\mu\text{g/kg/day}$
Estimated dose to Stauffer residents who drank 8 glasses of water a day	0.8 $\mu\text{g/kg/day}$
Estimated dose to Stauffer residents who drank 4 glasses of water a day	0.4 $\mu\text{g/kg/day}$

For people who drank 4 to 8 glasses of water a day, their estimated dose was similar to the dose in the Chinese study that did not show harmful effects. The estimated dose is also well below the levels that cause noncancerous harmful effects to the skin. It is important to realize that exposure

²³ Arsenic-induced keratosis is a skin condition found most often on the feet and palms. Many small depressions occur in the skin with small, hard, outgrowths of skin in the center of each depression. Keratosis can also appear as scaling skin. Hyperpigmentation of the skin occurs as small brown areas or blotches on the skin around the eyelids, temples, neck, nipples, and groin. In severe cases, pigmentation might cover the chest, back, and stomach. It sometimes appears as mottling on the skin and has been described as looking like raindrops. If mottling occurs, it is more frequent on the chest, back, and stomach.

has to occur for 10 to 40 years before damage to the skin occurs. Knowing that 10 to 40 years of exposure is needed adds some uncertainty in deciding whether or not harmful effects might occur because ATSDR only has information about arsenic levels in the wells for 1 year (March 2000). Should arsenic levels in the wells go down, the risk of harmful effects would decrease; should arsenic levels in the wells go up, the risk of harmful effects might be increased should the same people continue to drink the water for several decades. It is important to know that drinking the water one time, a few times, or even for a few years is not likely to cause the noncancerous skin problems mentioned because the exposure period is too short (ATSDR 2000b).

Arsenic-induced skin problems were seen in children, but about 10 years of exposure is required before skin problems occur. Although the estimated dose in adults remains relatively constant throughout adulthood, the estimated dose in children changes as they grow older because their body weight increases. This change in body weight makes it difficult to determine a constant dose over their preschool and school years. To evaluate children, therefore, ATSDR estimated an average dose for preschool children and an average dose for elementary school children. Like adults, these average doses are shown in comparison to the LOAEL and NOAEL:

LOAEL from Chinese study	14.0 $\mu\text{g/kg/day}$
NOAEL from Chinese study	0.8 $\mu\text{g/kg/day}$
Estimated dose for preschool children who drank 4 glasses of water a day	1.6 $\mu\text{g/kg/day}$
Estimated dose for elementary school children who drank 4 glasses of water a day	0.7 $\mu\text{g/kg/day}$
Estimated dose for teenagers who drank 4 glasses of water a day	0.4 $\mu\text{g/kg/day}$
Estimated dose for teenagers who drank 8 glasses of water a day	0.8 $\mu\text{g/kg/day}$

It is difficult to determine whether children are at risk for harmful effects from arsenic because their estimated dose varies as they grow older, decreasing from 1.6 to 0.7 to 0.4 $\mu\text{g/kg/day}$ (or 0.8 $\mu\text{g/kg/day}$ depending on how much water they drink). Nevertheless, the estimated dose for children is still below the LOAEL and is near the NOAEL. It is important to remember that for someone to be at risk, that person would have to drink 4 glasses of water a day from the well for 10 years or more. Drinking the water just a few times or for a few years would not be a problem.

In conclusion, it is unlikely that children or adults would experience noncancerous harmful effects from drinking water from the commercial wells or the one private well that contained elevated levels of arsenic.

5.6.2. Arsenic and the Possibility of Cancer

To evaluate whether or not arsenic in the three wells described in Table 51, Appendix B, could increase the risk of cancer, it is necessary to (a) quantitatively estimate a numerical cancer risk and (b) consider other weight-of-evidence information available for arsenic. EPA developed a mathematical equation that can be used to estimate a quantitative cancer risk. The equation has three components:

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- an estimate of dose (i.e., how much someone is exposed to and subsequently absorbs into their body),
- assumptions about how long someone will be exposed, and
- a cancer slope factor developed from human studies.

The mathematical equation looks like this:

Cancer risk = estimated dose × cancer slope factor × number of years of exposure.

EPA recently lowered the drinking water standard for arsenic from 50 ppb to 10 ppb. If someone were to drink 2 liters (8 glasses of water at 8 ounces per glass) of water every day for most of his or her life and this water contained 10 ppb arsenic, that person would have a small increased risk of cancer. Described quantitatively, if 10,000 people drank 2 liters of water every day that contained 10 ppb arsenic, between 0 and 4 extra cases of cancer might be expected. EPA acknowledges the uncertainty in their quantitative estimate of cancer risk, which is why the risk is described as 0 to 4. Another way of expressing this risk is 0 in 10,000 people exposed to 4 in 10,000 people exposed might get cancer if they drank the water daily throughout their lifetime.

When people drink water that contains 26 ppb arsenic (Table 51 in Appendix B), they, too, have a small increased risk of cancer. This cancer risk can be described as

If 10,000 people drank 2 liters of water every day that contained 26 ppb arsenic, between 0 and 10 extra cases of cancer might be expected. Another way of expressing this risk is 0 in 10,000 people exposed to 10 in 10,000 people exposed might get cancer if they drank 2 liters of water every day from these wells over a lifetime.

Human studies of people exposed to arsenic in drinking water showed that a minimum of 20 years of exposure is needed before cancer can be detected in people. Most arsenic-induced cancers required 30, 40, and 50 years of exposure from drinking water. For this reason, children are not likely to develop cancer from drinking arsenic-contaminated water. Their risk of increased cancer, however, comes from drinking arsenic-contaminated water as children and continuing to drink arsenic-contaminated water as adults.

The theoretical estimates of cancer risk presented in this discussion assumes many decades of exposure. For the three wells in which arsenic tested above EPA's drinking water standard, information about arsenic contamination comes from only one sample collected in March 2000. Because information is only available for one sample period, it is not possible to know whether people who drank from these wells are actually at risk for arsenic-induced cancers.

5.6.3. Lead and the Possibility of Harmful Effects

Lead was found in four residential wells at levels that exceeded EPA's action level of 15 ppb. The levels detected were 18, 24, 160, and 270 ppb. At the property with the highest lead level in well water (270 ppb), the well water showed varying levels of lead, as shown below:

March 2000	4.2 ppb
December 2000	1.2 ppb
March 2001	270.0 ppb
May 2001	1.5 ppb

Therefore, lead levels in water were elevated only one time. ATSDR staff members spoke with Pinellas County officials who reported that the well was sampled during a dry period and that the water was cloudy. Pinellas County officials also reported that the sample came from the well head or from near the well head and not from a faucet inside the house. No samples were taken after May 2001 and no tests are planned for the future. Pinellas County officials also reported that the well depth was not certain but that it was probably screened in the deeper Floridan Aquifer. The other wells that had lead at levels above EPA's proposed action level were sampled one time in either 2000 or 2001.

Generally, exposure to excessive levels of lead is a concern for preschool children and this concern results from exposure to lead throughout their preschool years. Because lead was elevated at 270 ppb only one time, the concern is whether or not exposure for just a few months could be a problem. Therefore, it is necessary to estimate how much a preschool child will be exposed to lead should that child drink water containing 270 ppb for a few months. To estimate a child's exposure, it is customary to assume that a preschool child will drink 2 to 4 glasses of tapwater a day with each glass having 8 ounces of water. The estimated exposure to lead for a preschool child drinking from the private well containing 270 ppb lead might cause changes in blood chemistry and mild effects to the liver. In boys, the exposure might cause mild effects to the prostate. These effects might also occur in preschool children who used the water containing 160 ppb lead but are probably not likely for preschool children who drank water containing 18 or 24 ppb lead (ATSDR 1999f).

5.7. Exposure to Contaminants in Soil and the Possibility of Harmful Effects

To evaluate soil contamination, ATSDR divided the soils data into on-site soil and off-site soil. Within on-site soils, the data are further divided into surface soil, pond soils, and slag. The soils data are presented in Table 2 (pond soils), Table 3 (slag), and Table 4 (surface soils) in Appendix B. Off-site soil data consists of samples from Gulfside Elementary School and are summarized in Table 11, Appendix B.

Adults and particularly children can be exposed to chemicals in soil from dust or dirt clinging to their hands. When people put fingers in their mouth or around their lips, they can swallow the dust

and dirt clinging to their hands. Preschool children ingest the largest amounts of dust and dirt because their play activity brings them into close contact with soil and they usually have the greatest amount of hand-to-mouth activity. Therefore, ATSDR pays close attention to the exposure that preschool children get from playing in soil. Elementary school children, teenagers, and adults also swallow small amounts of soil, so ATSDR also evaluates their exposure.

In addition, some workers might accidentally come into contact with contaminated soils. As an example, contractors and utility workers might work on job sites with contaminated soils. If these workers got arsenic-contaminated soils on their hands, then engaged in hand-to-mouth activity, they too could be exposed to the contaminants in the area.

5.7.1. Surface Soils, Pond Soils, and Slag at the Stauffer Facility

5.7.1.1. SVOCs

Several chemicals referred to as SVOCs or polycyclic aromatic hydrocarbons (PAHs) were detected in surface soils, pond soils, and slag from the Stauffer facility. The chemicals found were benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, dibenzo[a,h]anthracene, and indeno[1,2,3-cd]pyrene. About half of the 33 or so soil samples contained PAHs, with the highest level detected being 4.3 ppm. A few of the samples contained PAHs at levels above ATSDR's CVs; the data from these samples are further evaluated below. The levels detected in pond soils, slag, and surface soil can be found in Tables 2, 3, and 4, respectively, in Appendix B.

When deciding whether or not a chemical can cause harmful effects in people, it is important to realize that for long periods of exposure the average chemical concentration is used to estimate how much someone is exposed. When the few samples above a CV are averaged with the other soil samples that were below a CV value, the resulting average concentration of a chemical in soil is below ATSDR's CV. More importantly, the estimated dose for adults and children is far below levels that cause harmful effects. This conclusion applies to past exposures for workers who might have come in contact with soil, for people who might trespass on the property, and for future exposures should the site become residential.

5.7.1.2. Inorganic Metals

Several inorganic metals were detected in on-site pond soils, slag, and surface soils, and are summarized in Tables 2, 3, and 4, respectively, in Appendix B. A similar situation exists with most of the metals as with the PAHs discussed previously. For the metals antimony, cadmium, thallium, and vanadium, once the average concentration is determined, the concentration of the metal in soil is below ATSDR's CV and the estimated dose for people is far below levels that might be harmful. Therefore, these metals in soil are not harmful.

Arsenic was found in surface soils, pond soils, and slag. A summary of arsenic levels in each media is shown in Table 52 in Appendix B.

5.7.2. Arsenic and the Possibility of Noncancerous Harmful Effects

As mentioned previously, children and adults accidentally ingest small amounts of soil every day. Because nearby residents could not have come in contact with soils on the Stauffer facility, arsenic in soil could not have caused harmful effects in nearby residents. It is possible, however, that the Stauffer facility could become a residential neighborhood some day. Therefore, ATSDR will evaluate exposure to arsenic in soil from hand-to-mouth activity in adults and children based on this future scenario.

Children typically ingest less than 1/16 of a teaspoon of soil every day. Using the metric system, the typical preschool child ingests at most about 200 milligrams (mg) of soil every day, elementary school children and teenagers ingest at most 100 mg each day. These estimated intake levels for soil ingestion are believed to apply to only a small group of children; on average, most children typically ingest much smaller amounts of soil, for example, probably only 30 to 50 mg every day. Using 200 mg as a soil intake, it is possible to estimate how much some children will be exposed to arsenic in soil from hand-to-mouth activity. The estimated dose in children exposed to arsenic in surface soils, pond soil, and slag are shown in Table 53, Appendix B.

As a reminder, ATSDR's chronic MRL for arsenic is the dose below which harmful effects are not likely. For arsenic, the chronic MRL is 0.3 $\mu\text{g/kg/day}$ arsenic; therefore, whenever someone's estimated dose is below 0.3 $\mu\text{g/kg/day}$, harmful effects are not likely. As can be seen in Table 53 in Appendix B, all of the estimated doses from surface soil and slag for children and adults are below the chronic MRL. The same is true for pond soils except for the estimated dose for preschool children and 1-year-old children. The estimated dose in these two groups is 1.7 $\mu\text{g/kg/day}$ for some 1-year-old children and 1 $\mu\text{g/kg/day}$ for some preschool children. The estimated dose decreases as preschool children age and would eventually fall below the chronic MRL as those children enter elementary school. This occurs because children gain weight as they grow older and this lowers the estimated dose they receive.

The question to answer now is whether or not preschool children are truly at risk for harmful effects. The range of their estimated doses (1 to 1.7 $\mu\text{g/kg/day}$) is similar to the dose in human studies where no harmful effects were seen in people exposed to arsenic for 10 to 40 years. The estimated dose is also about 14 times lower than the dose in human studies that caused harmful effects to the skin. Should the site be developed, it is unlikely that children exposed to arsenic would actually develop skin problems from coming in contact with arsenic in pond soils because

- children would be exposed for only 5 or so years compared with the 10 to 40 years shown in the Chinese study to cause skin problems, and
- after 5 years of exposure, the estimated dose would be below the chronic MRL.

5.7.3. Arsenic and the Possibility of Cancer

Should the site become residential, it is necessary to determine whether arsenic in soil might increase the risk of some people getting cancer. As described previously, children and adults

accidentally ingest small amounts of soil every day. Therefore, it is necessary to determine if people would have an increased risk of cancer should their exposure continue for many decades. It is important to realize that a theoretical increase in the risk of cancer can be calculated from the naturally occurring arsenic soil. Table 54 in Appendix B shows the theoretical background risk for cancer from naturally occurring arsenic along with the increased risk from arsenic in pond soils and surface soil.

As Table 53 in Appendix B shows, as the average concentration of arsenic in soil increases, the theoretical increase in the risk of cancer for someone who lives in certain parts of the Stauffer property would increase. The risk of cancer is greatest for a home that would be built on the pond soils (an estimated 0 to 300 cancers for every 1,000,000 people exposed for their lifetime) and decreases for homes built in other parts of the Stauffer property. It is important to note that these estimates of cancer risk are very conservative because they assume that someone lives at a property their entire life and ingests the highest amounts of soil their entire life. If someone were to live at a property for half their life, that person's estimated risk of cancer would be half the risk shown in Table 53.

5.7.4. Surface Soil at Gulfside Elementary School

Arsenic was found in surface soil samples from Gulfside Elementary School at levels ranging from 0.13 to 0.6 ppm. ATSDR's CV (i.e., screening level) for arsenic in soil is 0.5 ppm, which means that whenever a level is higher than 0.5 ppm, ATSDR evaluates the chemical further. Arsenic occurs naturally in all soils; typical levels in soils from the Eastern United States are about 7 ppm, while background levels for arsenic in soil from Florida are about 5 ppm. Because the arsenic soil levels at Gulfside are at or below background levels of arsenic in soil, the arsenic levels are not a public health threat and no harmful effects are likely because of arsenic in soil at the school.

5.8. Exposures to Former Stauffer Workers

5.8.1. Background

Stauffer Chemical Company (Stauffer) operated in Tarpons Springs, Florida from 1947 through 1981 as a chemical plant that extracted elemental phosphorus from phosphate ore. The facility included a phosphate ore processing area, elemental phosphorus production facilities, a slag processing area, and a system of settling ponds. At the Stauffer facility, elemental phosphorus was extracted by combining coke and silica with phosphate rock in an electric arc furnace.

ATSDR was asked to evaluate past exposures to workers from Stauffer to determine whether past exposure might cause adverse health effects. To do this, ATSDR reviewed exposure monitoring data from the facility for the years 1975 through 1981. These data were collected using personal monitors (devices carried by workers) and area monitors from various departments and job

classifications throughout the facility (Table 55 in Appendix B). No quality assurance or quality control information was available for these data. The following reports were reviewed:

- Industrial Hygiene Program, Valid Area Data, Tarpon Springs, Volume II;
- Tarpon Springs, Employee Exposure Data, Reports 3–12, Historic + Current;
- Stauffer Industrial Records, Stauffer in Violation Even While Shut Down; and
- some additional data packages that contained written correspondence between EPA (Region 4) and Tarpon Springs community members, transcripts of meetings between Stauffer employees and OSHA officials, summaries of monitoring data, monitoring schedules, assorted raw monitoring data, internal memos from Stauffer, notifications of proposed OSHA penalties against the company, and safety instructions to Stauffer employees.

ATSDR screened the data provided to find the minimum concentration, maximum concentration, and frequency (Table 56 in Appendix B) for which Stauffer employees might have been exposed. This list of contaminants and their maximum concentrations were then compared to both occupational standards (Occupational Safety and Health Administration [OSHA], American Conference of Governmental Industrial Hygienists [ACGIH], and National Institute for Occupational Safety and Health [NIOSH]) and ATSDR's CVs to determine whether employees might have been exposed to levels of contaminants that might cause adverse health effects. ATSDR found several contaminants at levels that exceeded an occupational standard or an ATSDR CV (Table 57 in Appendix B). Each of these contaminants is evaluated further in the following sections.

5.8.2. Asbestos

From accounts of former workers and from Stauffer interoffice correspondence, we know that asbestos was used in several forms (rope asbestos, loose bag asbestos, and asbestos pipe insulation). Unfortunately, very little data are available on asbestos use at the facility. Interoffice correspondence from the early 1970s indicates that Stauffer was aware of OSHA's regulations about the hazards of working with asbestos and began work to identify asbestos exposure in the workplace, determine whether monitoring and/or employees examinations were needed, investigate alternatives for asbestos use in its operations, and inform employees that OSHA-approved respirators were required when working with asbestos-containing materials (ACM). Stauffer in Tarpon Springs was issued a citation by OSHA on April 7, 1975, for failure to comply with standards covering the proper handling and use of asbestos, failure to provide employee monitoring and medical examinations, and failure to post appropriate caution signs. Interoffice correspondence from April 8, 1975, describes actions taken or to be taken by the company to comply with OSHA regulations (i.e., monitoring, examinations, wet-handling methods, etc.).

Asbestos data available for ATSDR review were collected by Stauffer's industrial hygiene program in 1975 and 1976. ATSDR reviewed 13 area and/or personal samples collected in various locations within the plant. Some of these samples were collected while employees performed job tasks such as installing asbestos rope for electrode packing or cutting asbestos-

containing gaskets. Most of the industrial hygiene reports indicate that OSHA-approved respirators were worn during these sampling periods. Asbestos fiber counts ranged from 0 (no fibers detected) to 0.33 fibers per cubic centimeter (f/cc), which were below the OSHA permissible exposure limit (PEL)²⁴ of 0.5 f/cc during this time. The current OSHA PEL for asbestos is 0.1 f/cc, so some of the samples taken in 1975 and 1976 exceed the present standard (NIOSH 2001, OSHA 1991).

From personal accounts of former employees and from interoffice communications, we know that ACM was used at the Stauffer plant as insulation for piping, as a gasket material, and in both loose and rope forms. Stauffer employees were likely exposed to ACM during plant operations and maintenance, especially before development and implementation of OSHA standards for handling and use of ACM in the early to mid 1970s. It is difficult for ATSDR to assess past environmental exposures at Stauffer because of the lack of data, especially before 1975. What is known about the manufacturing and maintenance processes at Stauffer makes it likely that former employees were intermittently exposed from 1948 to the mid 1970s to ACM at levels above the current TWA of 0.1 f/cc. During the early 1970s, ACM continued to be used at Stauffer, but the company began requiring respiratory protection when handling ACM beginning in 1974 or 1975, according to interoffice correspondence. If employees were using respiratory protection in accordance with OSHA and company guidelines, exposure to ACM after 1975 should have been greatly reduced.

ATSDR used conservative assumptions to evaluate increased cancer risk (Table 58 in Appendix B) based on the maximum asbestos concentration found in the storeroom and asbestos room. ATSDR's evaluation indicates there might be a moderate increased risk of cancer due to worker exposures to asbestos at Stauffer (Table 58). The maximum concentration of asbestos exceeded ATSDR's CV of 0.000004 ug/m³, but it was more than 100 times lower than the lowest level known to cause non-cancerous effects (ATSDR 2001b); therefore, it is unlikely (based on air monitoring data) that workers are at risk when it comes to non-cancerous effects, such as asbestosis.

Workers who breathe in asbestos might develop a slow buildup of scar-like tissue in the lungs and in the membrane that surrounds the lungs. The scar-like tissue does not expand and contract like normal lung tissue and so breathing becomes difficult. Blood flow to the lung might decrease and cause the heart to enlarge, a disease called asbestosis. People with asbestosis have shortness of breath, often accompanied by a cough. This is a serious disease and can eventually lead to disability or death in people exposed to high amounts of asbestos. Changes in the membrane surrounding the lung, called pleural plaques, are quite common in people occupationally exposed

²⁴The PEL can be expressed as a time-weighted average (TWA) or a short-term exposure limit (STEL) that legally must never be exceeded instantaneously even if the TWA exposure limit is not violated. TWA is the maximum TWA concentration of a chemical to which an employee can be exposed for a normal 8-hour workday or 40-hour workweek.

to asbestos and are sometimes found in people living in areas with high environmental levels of asbestos, but effects on breathing are usually not serious.

Asbestos workers have increased chances of getting two types of cancer: cancer of the lung tissue itself and mesothelioma, a cancer of the thin membrane that surrounds the lung and other internal organs. Lung cancer is usually fatal, whereas mesothelioma is invariably fatal within a few months of diagnosis. These diseases do not develop immediately, but appear years after exposure. Studies of workers provide some evidence that breathing asbestos can increase the chances of getting cancer in other locations (for example, stomach, intestines, esophagus, pancreas, kidneys), but this is less certain.

The levels of asbestos in air that lead to lung disease depend on a number of factors. The most important of these are (a) how long a worker was exposed, (b) how long it has been since exposure began, and (c) whether a worker smoked cigarettes. Interactions between cigarette smoke and asbestos increase the chance of getting lung cancer. Also, scientific debate is occurring concerning the differences in the extent of the disease caused by different fiber types and sizes. Some of the differences might be due to physical and chemical properties of the different fiber types. For example, several studies suggest that the amphiboles (tremolite, amosite, and especially crocidolite) might be more harmful than chrysotile. However, most data indicate that fiber size (length and diameter) is the most important factor for cancer-causing potential, particularly for mesothelioma. Most studies indicate that long fibers (greater than about 1/5,000th of an inch) are more likely to cause injury than short fibers (less than about 1/10,000th of an inch). Generally, smaller fiber diameters or widths are associated with mesothelioma and larger widths are associated with lung cancer.

5.8.3. Arsenic

ATSDR found that approximately 43 personal or area samples were taken for arsenic between 1975 and 1978 at Stauffer. No data are available before 1975 for arsenic exposure. The maximum concentration of arsenic reported, in a personal sample from the furnace department, was below the level of detection (0.0005 mg/m³). This concentration did not exceed an occupational standard, but it did exceed the ATSDR CV of 0.0000002 mg/m³. Arsenic is classified as a known human carcinogen by EPA (ATSDR 2000b).

Based on ATSDR's evaluation it appears unlikely that adverse health effects, including cancer, would occur as a result of any arsenic exposures related to Stauffer.

5.8.4. Carbon Monoxide

ATSDR found approximately 96 samples taken for carbon monoxide between 1974 and 1980 at Stauffer. No data were available before 1974 for carbon monoxide exposure. The maximum concentration of carbon monoxide, in a grab sample collected in the furnace department, was

approximately 700 ppm. This concentration exceeds the threshold-limit value (TLV) of 25 ppm (ACGIH 2002). ATSDR has no toxicological profile or CV for carbon monoxide.

Repeated exposures to carbon monoxide at levels above the TLV, without respiratory protection, might cause adverse health effects in workers.

Carbon monoxide is a colorless, odorless gas that is about 3% lighter than air. When inhaled, carbon monoxide combines with hemoglobin in the blood, preventing absorption of oxygen and resulting in asphyxiation. Carbon monoxide is formed whenever carbon or substances containing carbon are burned with an insufficient air supply. Even when the amount of air is theoretically sufficient, the reaction is not always complete, so that the combustion gases contain some free oxygen and some carbon monoxide. Carbon monoxide produces headache, nausea, or fatigue, followed by unconsciousness.

Acute cases of poisoning resulting from brief exposures to high concentrations seldom result in any permanent disability, if recovery occurs. Chronic effects as the result of repeated exposure to lower concentrations can occur. Cardiac damage, auditory disturbances, and contraction of the visual fields have been seen. Studies of workers have found that where poisoning has been long and severe, cerebral congestion and edema (swelling of tissue) might occur, resulting in long-lasting mental or nervous system damage.

5.8.5. Hydrogen Sulfide

ATSDR found that three samples were taken for hydrogen sulfide in 1978 at Stauffer. No data are available before 1978 for hydrogen sulfide exposure. The maximum concentration of hydrogen sulfide, in a grab sample from the phosphorus handling department, was approximately 60 ppm. This concentration exceeds the TWA of 10 ppm for an 8-hour workday and the 15 ppm STEL (NIOSH 2001, OSHA 1991).

Repeated exposures to hydrogen sulfide at levels above the TWA or STEL, without respiratory protection, would likely cause adverse health effects in exposed workers. The maximum concentration of hydrogen sulfide also exceeded ATSDR's CV, so ATSDR compared the maximum concentration to intermediate inhalation studies in its *Toxicological Profile for Hydrogen Sulfide* (ATSDR 1999c). The maximum concentration exceeded the LOAEL for animals of 20 ppm. This LOAEL is based on a study of rat dams (female rats) exposed to 20, 50, or 75 ppm hydrogen sulfide for 7 hours per day for 21 days. Repeated exposures to hydrogen sulfide at the levels found at Stauffer might cause adverse health effects if respiratory protection was not used (ATSDR 1999c).

Breathing hydrogen sulfide at concentrations greater than 500 ppm can be fatal within just a few minutes. Death is usually preceded by a loss of consciousness after one or more breaths, although a loss of consciousness does not necessarily mean that death will follow. Hydrogen sulfide is considered a "broad spectrum" poison. This means that it can poison several different systems in

the body. The variety of activity might be the reason that no single antidote, or treatment, has been found for hydrogen sulfide poisoning. Hydrogen sulfide can be especially dangerous because at concentrations over 100 ppm it is difficult to smell. Deaths due to breathing large amounts of hydrogen sulfide were reported in a variety of different work settings, including sewers, animal processing plants, waste dumps, sludge plants, oil and gas well drilling sites, and tanks and cesspools. Lower concentrations of hydrogen sulfide exposure might cause eye irritation, a sore throat and cough, shortness of breath, and fluid in the lungs. Breathing of hydrogen sulfide on a long-term basis might result in fatigue, loss of appetite, headaches, irritability, poor memory, and dizziness.

5.8.6. Lead

ATSDR found that four samples were taken at Stauffer for lead in 1981. No data are available before 1981 for lead exposure. The maximum concentration of lead, in a personal sample from the mechanical department, was 0.423 mg/m³. This concentration exceeds the TWA of 0.05 mg/m³ (NIOSH 2001, OSHA 1991). ATSDR has no CV for inhalation of lead.

ATSDR compared the maximum concentration of lead found in air to intermediate inhalation exposure information in its *Toxicological Profile for Lead* (ATSDR 1999f). The maximum concentration was above the LOAEL of 0.01 mg/m³ for less serious effects in humans (ATSDR 1999f). This LOAEL is based on a study of adult male volunteers exposed to particulate lead in air at 0.003 or 0.01 mg/m³ for 23 hours a day for 3–4 months that caused hematologic²⁵ changes (ATSDR 1999f). Repeated exposures without respiratory protection to lead at the levels found at Stauffer might cause adverse health effects in exposed workers.

Lead can affect almost every organ system in the body. The most sensitive is the central nervous system, particularly in children. Lead might also damage the kidneys, the male reproductive system (the organs responsible for sperm production), and cause spontaneous abortion. The effects are the same whether lead is inhaled or swallowed. At high levels, exposure to lead might decrease reaction time; cause weakness in fingers, wrists, and ankles; and possibly affect memory. Lead can also cause anemia, a disorder of the blood.

Inadequate evidence exists to clearly determine lead's carcinogenicity in people. Kidney tumors have developed in rats and mice given large doses of lead, but these studies were criticized for using very high doses and should not be used to predict what might happen in humans. The Department of Health and Human Services determined on the basis of animal studies that lead acetate and lead phosphate might be anticipated to be carcinogens, but again inadequate evidence exists for the carcinogenicity of these lead compounds in humans.

²⁵Changes in the formation of blood or blood cells.

5.8.7. Nickel

ATSDR found that eight samples were taken for nickel in 1981 at Stauffer. No data are available before 1981 for nickel exposure. The maximum concentration of nickel, in a personal sample collected in the mechanical department, was 0.26 mg/m^3 . This concentration exceeded the TWA of 0.10 mg/m^3 and the ATSDR chronic MRL²⁶ of 0.0002 mg/m^3 (ATSDR 1997b; NIOSH 2001, OSHA 1991). Nickel is considered possibly carcinogenic to humans by the International Agency for Research on Cancer and the Department of Health and Human Services.

ATSDR compared the maximum concentration of nickel found in air to chronic inhalation exposure information in its *Toxicological Profile for Nickel* (ATSDR 1997b). The maximum concentration was below the Cancer Effect Level of 10 mg/m^3 established for an occupationally exposed population, but exceeded the lowest Cancer Effect Level of 0.11 mg/m^3 established in a 2-year rat study. The CEL is based on an epidemiological study of refinery workers exposed to nickel compounds at concentrations greater than 1 mg/m^3 that found an increased incidence of lung and nasal cancer (ATSDR 1997b).

The maximum level of nickel detected at Stauffer also exceeded the chronic LOAEL of 0.06 mg/m^3 for less serious (non-cancerous) effects in animals (ATSDR 1997b). The LOAEL is based on a study of rats exposed to 0.06 mg/m^3 of nickel oxide 23 hours per day, 7 days per week for life that caused increased lung weight, congestion, and alveolar proteinosis (ATSDR 1997b). Repeated exposures without respiratory protection to nickel at the levels found at Stauffer could potentially cause adverse health effects in exposed workers.

The most common adverse effect of nickel in humans is an allergic reaction. People can become sensitive to nickel when jewelry or other things containing nickel are in direct contact with the skin. Once a person is sensitized to nickel, further contact with the metal will produce a reaction. The most common reaction is a skin rash at the site of contact. People who are sensitive to nickel have reactions when nickel comes into contact with the skin. Some sensitive persons might have a reaction when they eat nickel in food or water, or breathe dust containing nickel. More women are sensitive to nickel than are men. The difference between men and women is thought to be a result of greater exposure to women to nickel through jewelry and other metal items. The most serious effects of nickel, such as cancer of the lung and nasal sinus, occurred in people who breathed nickel dust while working in nickel refineries or in nickel processing plants. EPA determined that nickel refinery dust and nickel subsulfide are human carcinogens.

²⁶The MRL is an estimate of daily human exposure to a dose of a chemical that is likely to be without an appreciable risk of adverse noncancerous health effects over a specified duration of exposure.

5.8.8. Phosphorus and Related Compounds

ATSDR found that 62 samples were taken at Stauffer for phosphorus (including data listed as phosphorus or yellow-phosphorus) between 1976 and 1981. No data exist before 1976 on phosphorus. The maximum concentration of phosphorus, in a personal sample from the phosphorus handling department, was $255.67 \mu\text{g}/\text{m}^3$ or $0.255 \text{ mg}/\text{m}^3$. This concentration exceeded the TLV of $0.10 \text{ mg}/\text{m}^3$ for occupational exposure, but it was below the ATSDR CV of $20 \text{ mg}/\text{m}^3$ (ATSDR 1997a; NIOSH 2001, OSHA 1991).

Repeated exposures without respiratory protection to phosphorus at levels above the TLV might cause adverse health effects in workers. However, ATSDR compared the maximum concentration of phosphorus found in air to intermediate inhalation exposure information in its *Toxicological Profile for White Phosphorus* (ATSDR 1997a). The maximum concentration was thousands of times lower than the LOAEL ($884 \text{ mg}/\text{m}^3$), indicating that adverse health effects are not likely from exposure at this level (ATSDR 1997a).

Breathing in white phosphorus can cause the development of a cough or a condition known as phossy jaw that involves poor wound healing in the mouth and breakdown of the jawbone. Phossy jaw generally occurs following long term exposure to airborne white phosphorus. Damage to the blood vessels of the mouth has been seen in rats breathing air containing white phosphorus. Breathing white phosphorus smoke can damage the lungs and throat. Most of what is known about the health effects of breathing this compound is from studies of workers. Eating or drinking white phosphorus can cause vomiting; stomach cramps; or liver, heart, or kidney damage. Ingestion can also cause extreme drowsiness or death. Skin contact with white phosphorus can result in severe burns (ATSDR 1997a).

Phosphine and phosphoric acid are two other phosphorus-related compounds evaluated using data available from Stauffer.

5.8.8.1. Phosphine

ATSDR found that 10 samples were taken for phosphine between 1975 and 1978 at Stauffer. No data are available before 1975 for phosphine exposure. The maximum concentration of phosphine, in a grab sample collected in the phosphorus handling department, was approximately 7 ppm or $9,893 \mu\text{g}/\text{m}^3$. This concentration exceeds the TLV of 0.30 ppm for occupational exposure and exceeds the ATSDR CV of $0.30 \mu\text{g}/\text{m}^3$ (ATSDR 1997a, NIOSH 2001, OSHA 1991). ATSDR does not have a toxicological profile for phosphine, but information can be found in the *Toxicological Profile for White Phosphorus* (ATSDR 1997a).

Repeated exposures without respiratory protection to phosphine at levels above the TLV might cause adverse health effects in workers.

Phosphine is a highly toxic gas generated from phosphide. When phosphine is inhaled, it can react with moisture in the lungs to form phosphoric acid, which can cause blistering and edema (fluid in the lungs). These effects can be serious or even fatal. Exposure to phosphine has also been linked with other health effects such as chest tightness, headache, dizziness, and nausea. Intermittent, low concentrations of phosphine gas (probably 0.08 to 0.03 ppm) have been associated with mild headaches. Higher intermittent concentrations (0.40 to 35 ppm) have been linked to diarrhea, nausea, abdominal pain, vomiting, tightness of chest, headache, dizziness, staggering and skin irritation (NIOSH 1999).

5.8.8.2. Phosphoric Acid

ATSDR found that approximately 15 samples were taken for phosphoric acid between 1977 and 1979 at Stauffer. No data are available before 1977 for phosphoric acid exposure. The maximum concentration of phosphoric acid, in a grab sample from the phosphorus handling department, was 4.06 mg/m³. This concentration exceeded the TLV of 1 mg/m³ and exceeded the ATSDR CV of 0.01 mg/m³ (ATSDR 1997a, NIOSH 2001, OSHA 1991). ATSDR does not have a toxicological profile for phosphoric acid, but information can be found in the *Toxicological Profile for White Phosphorus* (ATSDR 1997a).

Repeated exposures without respiratory protection to phosphoric acid at levels above the TLV might cause adverse health effects in workers.

Phosphoric acid is formed when phosphorus reacts with oxygen and water. Inhalation effects are similar to those of phosphorus and phosphine.

5.8.9. Sulfur Dioxide

ATSDR found that 59 samples were taken for sulfur dioxide between 1979 and 1981 at Stauffer. No data were available before 1979 for sulfur dioxide exposure. The maximum concentration of sulfur dioxide, in a personal sample collected in the mechanical department, was 1.39 ppm or 1,390 ppb. This concentration did not exceed an occupational standard, but it did exceed the ATSDR CV of 10 ppb.

ATSDR compared the maximum concentration of sulfur dioxide found in air to chronic inhalation exposure information in its *Toxicological Profile for Sulfur Dioxide* (ATSDR 1998). The LOAEL for animal studies was 5.7 ppm (ATSDR 1998). This LOAEL is based on a study of guinea pigs that were exposed by inhalation to 5.7 ppm sulfur dioxide for 22 hours per day, 7 days per week, for 52 weeks. These guinea pigs experienced cardiovascular, hematological, and hepatic effects (ATSDR 1998). Former Stauffer workers are not likely to have experienced these same effects because they were not exposed to sulfur dioxide at the levels or frequencies experienced by the animals in this study, however long-term exposure to sulfur dioxide can cause adverse health

effects, i.e., lung function changes have been observed in some workers exposed to 0.30–0.40 ppm sulfur dioxide for 20 years or more. However, these workers were exposed to other chemicals, making it difficult to attribute their health effects to sulfur dioxide exposure alone (ATSDR, 1998).

Additionally, exercising asthmatics are sensitive to the respiratory effects of low concentrations (0.25 ppm) of sulfur dioxide. Inhalation of sulfur dioxide at high levels can be life-threatening. Exposure to 100 ppm of sulfur dioxide in air is considered immediately dangerous to life and health.

5.8.10. Total Dust, Quartz, and Silica

ATSDR found that approximately 66 samples were taken for nuisance dust, respirable dust, or total dust between 1972 and 1975 at Stauffer. Approximately 63 samples were also taken for quartz between 1979 and 1980 and approximately 63 samples taken for silica between 1975 and 1980. These samples were a mix of both personal and area samples collected from the furnace, yard, phosphorus handling, and kiln departments. No data are available before 1972 for dust, quartz, or silica.

Maximum values for dust, quartz, and silica all exceeded either a current or former occupational standard (NIOSH 2001, OSHA 1991). ATSDR has no CVs for dust, quartz, or silica.

On the basis of this information, it is likely that former workers at Stauffer were periodically exposed to levels of dust, quartz, and silica above occupational standards. Repeated exposures, without respiratory protection, might cause adverse health effects in former workers.

Inhalation of dust, quartz, and silica may all cause irritation of the respiratory tract. In occupational settings most samples for total dust contain some quartz and/or silica. Quartz is one of the three most common types of silica. To cause respiratory effects the particles of dust, quartz and silica must be small enough to be inhaled and deposited in the respiratory tract.

Occupational exposures to respirable crystalline silica²⁷ (or silica) are associated with the development of silicosis, lung cancer, pulmonary tuberculosis, and airway diseases (i.e. chronic obstructive pulmonary disease, such as, bronchitis or emphysema). These exposures may also be related to the development of autoimmune disorders, chronic renal disease, and other adverse health effects. Recent epidemiologic studies demonstrate that workers have a significant risk of developing chronic silicosis when they are exposed to silica over a working lifetime at the current OSHA permissible exposure limit (NIOSH 2002).

²⁷ Respirable crystalline silica is that portion of airborne crystalline silica that is capable of entering the gas-exchange regions of the lungs, if inhaled.

Silicosis is the disease most commonly associated with crystalline silica exposure. Silicosis is a fibrosis of the lungs resulting in shortness of breath caused by inhalation of silica dusts. There are two types of silicosis: acute and chronic. Acute silicosis may develop shortly after exposure to high concentrations of respirable crystalline silica, while chronic silicosis usually develops years after exposure to relatively low concentrations. Some studies have found that chronic silicosis can develop even after occupational exposure has ceased. Probably the most important factor in development of silicosis is the “dose” of respirable silica-containing dust in the workplace setting. The dose is the product of the concentration of dust containing respirable silica in the workplace air and the percentage of respirable silica in the total dust. Other important factors are the particle size, the nature of the silica (crystalline or noncrystalline), the duration of the dust exposure, and the varying time period from first exposure to diagnosis (NIOSH 2002).

Silicosis may sometimes be complicated by severe mycobacterial or fungal infections. About half of these infections are caused by *Mycobacterium tuberculosis* and result in TB. Epidemiologic studies have firmly established that silicosis is a risk factor for developing TB. The carcinogenicity of silica in humans has been strongly debated in the scientific community. Several studies suggest that crystalline silica be considered a potential occupational carcinogen, but further research is needed to determine the relationship between silica dust exposure and increased lung cancer risk (NIOSH 2002).

5.8.11. Total Chromium

ATSDR found that eight samples were taken in 1981 at Stauffer for total chromium. No data are available before 1981 for chromium exposure. The maximum concentration of total chromium, in a personal sample from the mechanical department, was 0.46 mg/m³ or 460 µg/m³. This concentration exceeded the occupational standard for chromium(VI)²⁸ of 0.01 mg/m³ and the ATSDR CV of 0.10 µg/m³ (ATSDR 2000c, NIOSH 2001, OSHA 1991). Chromium (VI) is considered a human carcinogen by EPA.

ATSDR used conservative assumptions to calculate increased cancer risk based on the maximum concentration of chromium. Using these assumptions, ATSDR considers a significant increased risk for cancer as a result of exposure to chromium (Table 58 in Appendix B). However, it is unlikely that a worker would have been exposed to chromium in the workplace as frequently as ATSDR assumed in its calculations; also, ATSDR assumed that the exposure was to chromium(VI) (the more toxic form). ATSDR also compared the maximum concentration of total chromium found in air at Stauffer to chronic inhalation exposure information in its *Toxicological Profile for Chromium* (ATSDR 2000c). The maximum concentration was above the LOAEL of 0.004 mg/m³. This LOAEL was based on a study of chrome platers exposed to 0.004 mg/m³ of chromium (VI) compound, via inhalation, for an average of 5.3 years that affected renal function

²⁸The most common forms of chromium are chromium(III) and chromium(VI). Generally, chromium(VI) is considered the more toxic form and therefore has a lower occupational exposure limit. Because the samples for chromium were not speciated, ATSDR used the most conservative standard [chromium(VI)] for comparisons.

(ATSDR 2000c). Repeated exposures to chromium [especially chromium (VI)] at the levels found at Stauffer, without respiratory protection, would likely cause adverse health effects in exposed workers.

Health effects resulting from exposure to chromium(III) and chromium(VI) are fairly well described in literature. Breathing high levels (greater than $2 \mu\text{g}/\text{m}^3$) of chromium(VI) can cause irritation to the nose, such as runny nose, sneezing, itching, nosebleeds, ulcers, and holes in the nasal septum. These effects have primarily occurred in factory workers who make chromium(VI) for several months to many years. Long-term exposure to chromium has been associated with lung cancer in workers exposed to levels in air that were 100 to 1,000 times higher than those found in the natural environment. Lung cancer can occur long after exposure to chromium has ended. It is not clear which forms of chromium are capable of causing lung cancer in workers. Chromium(VI) is believed to be primarily responsible for the increased lung cancer rates observed in workers who were exposed to high levels of chromium in workroom air. Breathing in small amounts of chromium(VI) for short or long periods does not cause a problem in most people. However, high levels of chromium in the workplace have caused asthma attacks in people who are allergic to chromium. Ingesting small amounts of chromium(VI) will generally not cause harm, but ingestion of larger amounts might cause stomach upsets, ulcers, convulsions, kidney and liver damage, or death. Workers handling liquids or solids that have chromium(VI) in them have developed skin ulcers.

Breathing in chromium(III) does not generally cause irritation to the nose or mouth in most people. Chromium(III) in small amounts is an important nutrient needed by the body but, as with chromium(VI), ingesting large amounts of chromium(III) might cause health problems.

Some people have been found to be extremely sensitive to chromium(VI) or chromium(III). Allergic reactions consisting of severe redness and swelling of the skin have been noted.

5.8.12 Tracing Project and Cause of Death Information for Former Workers

In 2003, the University of South Florida, School of Public Health along with the FDOH conducted a tracing project of Stauffer former workers, using a list constructed of Stauffer company records, and also determined cause of death for deceased former workers.

The former worker database contains the names of 2417 individuals of which 2318 (95.9%) were male. Former workers were located for the collection of information by a variety of methods. Cause of death information for former workers was identified by use of a National Death Index (NDI) Plus Search. Results show that 933 (38.7%) alive former workers were located by either full or partial address. A total of 864 (35.7%) were identified as deceased. This totals 1797 (74.3%) individuals located or identified as deceased.

The efforts made to locate former workers were extensive and included using such things as telephone directories, real estate records, Social Security Death Index (SSDI), and the NDI. Many

of the workers were at the facility more than 30 years ago making it very difficult to locate them with such old information. In addition, some of the databases do not cover the entire time period or persons of interest. For example, the NDI started in 1979 so any deaths before that are not available and the SSDI only includes those deaths for which a claim was filed. Locating 74% of a cohort which is this old and with limited information is quite good, and it is unlikely that further efforts to locate the missing individuals would be productive.

Cause of death was identified for 551 (63.8%) of 864 deceased former workers. Ages of the decedents was found in the Stauffer Chemical Company Plant Former Worker database. For all decedents, mean age of death was 59.8 years and the median age was 64 years.

Of those deceased, cause of death was confirmed for 551 (63%). Malignant neoplasms (various cancers) were the cause of 28% (157) of the deaths. There were no cases of mesothelioma or bone cancer identified. Respiratory diseases other than lung cancer accounted for 9%. For non-cancer causes of death, ischemic heart disease was the leading cause of death (19%), followed by respiratory disease (9%), other forms of heart disease (7%), and then cerebrovascular disease (5%). In comparison, leading cause of death for Florida males age 65 and older (1999-2000) was heart disease, followed by malignant neoplasm (various cancers), chronic lower respiratory diseases, cerebrovascular diseases, and diabetes mellitus. There was some similarity for the order of ranking for cause of death between the worker cohort and Florida older males.

5.8.13. Uncertainty and Limitations

Uncertainty exists for several reasons in ATSDR's evaluation of exposure and the possibility of harmful effects in workers from Stauffer in Tarpon Springs, Florida. Following are the some of the uncertainties and/or limitations in estimating exposure for former workers:

1. Arguably, the biggest limitation is the lack of exposure information for the period 1947 to 1970 – almost 25 years of Stauffer operations.
2. ATSDR based its evaluation of estimated exposure on the maximum level detected and assumed that some workers were exposed to these levels for up to 20 years. In fact, workers are likely to have been intermittently exposed to levels above and below the maximum level detected over the course of their employment at Stauffer. ATSDR used the maximum concentration rather than average concentration in its calculations because of the limited data from Stauffer.
3. ATSDR has no information to determine the length of worker exposures at Stauffer. ATSDR assumed a worst-case scenario: that workers were exposed to the maximum concentration of a contaminant for 8 hours per day, 40 hours per week. However, in most occupational settings, workers are not exposed to a maximum contaminant concentration for 8 hours per day, 40 hours per week. A more reasonable assumption is that a worker might perform a particular task (i.e., cutting asbestos gaskets) once or

twice per week for 20–30 minutes at a time. Accurate information on the length of actual exposure to contaminants at Stauffer would probably lower the length of exposure used in ATSDR's calculations, thereby reducing the possibility of adverse health effects associated with some contaminants.

4. ATSDR has very little information on the use of respiratory protection or other personal protective equipment (PPE) at Stauffer. As a worst-case scenario, ATSDR assumed that no respiratory protection or PPE was worn by workers. However, it is likely that, beginning in the 1970s, workers began wearing respiratory protection and PPE per company and OSHA guidelines. The use of respiratory protection and PPE beginning in the mid 1970s would most likely have lowered worker exposures from that time until the plant was closed in 1981.
5. ATSDR assumed that all of the data provided for its review was accurate, even though there was no quality assurance or quality control information provided to support this assumption.
6. ATSDR used its CVs to determine whether adverse health effects in former workers at Stauffer might have resulted from exposures to contaminants. ATSDR's CVs are based on 24-hour-per-day exposures and were not meant to be used in assessing occupational exposures, which are generally 8-hour-per-day exposures. Therefore, any conclusions reached from using the CVs to estimate worker exposures must be interpreted with caution.
7. The only pathway evaluated by ATSDR was inhalation exposure for former workers at Stauffer, because only air monitoring data were available. It is likely that former workers at Stauffer might also have been exposed to some contaminants by dermal contact, but ATSDR has no data to evaluate this potential pathway. Any additional exposure to contaminants via dermal contact (absorption) would increase the possibility of adverse health effects in former workers at Stauffer.
8. Approximately 26% of former workers could not be successfully traced in order to determine vital status or place of residence.

5.8.14. Summary of Exposure Findings

ATSDR reviewed and evaluated available worker exposure data for the Stauffer Superfund site, which operated from 1948 through 1981. The data available for evaluating occupational exposures are limited and covers only the last 10 years that the facility was in operation (1972–1981). No occupational exposure data were available for the first 25 years of the facility's operation.

The data and interoffice correspondence reviewed support the fact that workers were exposed to many contaminants during the process of extracting phosphorus from phosphate ore and during maintenance activities. However, it is difficult to assess, on the basis of the limited data, whether these exposures might have been at sufficient levels and of sufficient duration to cause possible adverse health effects. The data reviewed indicate exposures to some contaminants at Stauffer between 1972 and 1981 were in excess of current OSHA standards (Table 57). Because worker exposures occurred during this time in excess of OSHA regulations, we can probably assume these exposures would extend back through the years for which no data exists.

It is apparent, through interoffice correspondence, that Stauffer began evaluating worker exposures in the 1970s to comply with regulations from the Occupational Safety and Health Act, which became effective in April 1971. Correspondence indicates that Stauffer began recommending respiratory protection for handling ACM around 1974 or 1975 and then began implementing a respiratory protection program for other contaminants in the mid to late 1970s, as need was identified. It is unlikely that respiratory protection was used before the mid 1970s for working with ACM or chemicals at Stauffer. Therefore, workers using ACM or handling chemicals in the facility before the mid 1970s had a much higher probability of being overexposed, especially in job classifications in which documented exposures at levels above occupational standards occurred in later years.

On the basis of the review of data and information provided, ATSDR concludes the following:

1. Former workers at Stauffer were intermittently exposed to asbestos or ACM at levels that indicate an increased theoretical risk for lung cancer, but it is unlikely (based on air monitoring data) that workers are at risk for asbestosis.
2. Former workers at Stauffer were intermittently exposed to nickel and chromium at levels that indicate an increased theoretical risk of lung and/or nasal cancer.
3. Former workers at Stauffer were intermittently exposed to carbon monoxide, chromium, hydrogen sulfide, lead, nickel, phosphorus compounds, sulfur dioxide, total dust, quartz, and silica at levels that can cause adverse health effects.

5.8.15. Discussion and Recommendations

Because ATSDR's evaluations indicate that former workers at Stauffer were occupationally exposed to asbestos and/or other contaminants at levels that might cause adverse health effects, including certain cancers, ATSDR set out to identify appropriate health conditions or diseases to study. This task proved difficult because (1) former workers were exposed to a number of different chemicals, (2) no exposure data is available for many years of the plant's operations (i.e., late 1940s to early 1970s), (3) no specific length of exposure or length of employment information is available for the majority of former workers, (4) the available exposure data are limited and contain uncertainties, and (5) a large percentage of former workers (approximately 61%) are either

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deceased (36%) or their vital status or whereabouts is unknown (26%). (Note: ATSDR acknowledges that some former workers were likely overexposed to various chemicals prior to the time workplace monitoring began (i.e., before the early 1970s).)

Based on the factors discussed above, including limited industrial hygiene exposure data, ATSDR does not believe that a scientific health study of former Stauffer workers is feasible at this time; however, ATSDR will reevaluate this decision if new exposure data become available. Nevertheless, as a service to former workers, ATSDR is considering other follow-up health activities. More specifically, ATSDR is exploring the appropriateness and feasibility of conducting health screening/medical evaluation of former workers. The intent of this activity would be to provide (1) a meaningful service to former workers that may improve workers' preventive health practices and choices, e.g., annual vaccinations for respiratory diseases; (2) certain medical tests results to inform workers and their personal physicians in support of future medical decision making, and (3) information to raise the level of health awareness of workers and their family regarding possible health risks from past exposures. To further explore opportunities for appropriate health screening, ATSDR plans to convene a meeting of medical and epidemiologic experts in order to seek guidance and recommendations for possible health screening or interventions. ATSDR proposes to incorporate the input and questions of some former workers from the community for this meeting to ensure that the experts learn first hand the various working conditions over time to which former workers were subjected. ATSDR plans to hold this meeting in May 2003, depending upon the experts' availability. Stakeholders will be notified of this meeting, in advance, in order to provide the names of former workers who may be invited to provide personal testimony. It should be noted that the goal of this panel meeting would be to gather scientific and medical input, not to reach consensus. Also, this meeting does not guarantee the implementation of follow up health activities, nor does it signify the availability of funding for such activities.

6. CHILD HEALTH INITIATIVE

To ensure that the health of the nation's children is protected, ATSDR implemented an initiative requiring that public health assessments specifically evaluate the potential for children being exposed to site-related hazardous waste and whether or not the health of children might be affected.

This public health assessment reflects ATSDR's concern about protecting children's health from toxic chemicals in the environment. Specifically, ATSDR evaluated the potential for harmful effects occurring in children in the following scenarios:

- children being exposed to contaminants in air, especially particulate matter and sulfur dioxide, and the possibility of harmful effects;
- children with asthma as a sensitive subpopulation;
- children exposed to contaminants in drinking water;
- children's exposure to contaminants in soil;
- children who attended Gulfside Elementary School; and
- children who eat large amounts of dirt (children with soil-pica behavior) and the possibility of harmful effects.

These six topics are described in more detail in the Public Health Implications section.

7. DISCUSSION OF COMMUNITY CONCERNS

ATSDR established a community forum called the Neighbor-2-Neighbor (N-2-N) Committee to help ATSDR solicit community concerns and inform and educate residents living near the Stauffer site. The N-2-N Committee consists of nontechnical and technical community representatives who have volunteered to serve as champions for their community. ATSDR staff members met several times with the N-2-N Committee and other interested stakeholders to address health and environmental concerns. Additional concerns were received from the ATSDR Ombudsman report (ATSDR 2000a), community-wide meetings, and telephone calls received via the ATSDR toll-free line. These concerns and ATSDR's responses are listed below.

7.1. Health Concerns

1. ATSDR should provide medical treatment to former Stauffer workers.

ATSDR Response: ATSDR does not have the legal authority to provide medical care or treatment to people who were exposed to hazardous substances, even if their exposure has made them ill.

2. ATSDR needs to consider children's exposures and health effects separately from adults.

ATSDR Response: ATSDR agrees. As mentioned previously in the Child Health Initiative section, ATSDR evaluated the children's exposure for numerous scenarios involving exposure to contaminants in air, water, and soil. These areas are described in more detail in the Public Health Implications section.

3. Can ATSDR evaluate arsenic exposure, especially to children?

ATSDR Response: Yes. ATSDR reviewed environmental data specifically for arsenic, estimating how much arsenic children might be exposed to should they come in contact with arsenic in soil or drinking water. Using these estimates, ATSDR determined whether or not harmful effects might be possible. Children and the potential for arsenic exposure and harmful effects are described in more detail in the Public Health Implications section.

4. Can ATSDR address the risk of multiple exposures to the same or different chemicals?

ATSDR Response: Yes, to a limited extent. When evaluating air emissions from the Stauffer facility while it was operating, ATSDR evaluated the combination of exposures that occur in air contaminated with particulate matter, sulfur dioxide, and other pollutants. Some information shows that particulate matter and sulfur dioxide are both involved somehow in heart and lung disease. What is uncertain is whether the

chemicals actually cause heart and lung disease or increase the severity of preexisting heart and lung disease.

5. Can exposure to chemicals coming from the Stauffer site cause Hodgkin disease, Parkinson disease, tumors, migraines, cancers (colon, bone), thyroid disease, neurologic problems, nosebleeds, joint pains, strokes, asthma, diabetes, lung disease, headaches, ulcers, problems breathing, skin lesions, pulmonary lung disease, upper respiratory problems, high blood pressure, severe allergies, and shortness of breath?

ATSDR Response: Exposure to these chemicals emitted while Stauffer was operating are associated with some of these health problems. From the question 5 list, exposure to particulate matter and sulfur dioxide are associated with the following:

- cancer,
- asthma,
- lung disease,
- headaches,
- problems breathing,
- pulmonary lung disease,
- upper respiratory problems, and
- shortness of breath.

A description of all the possible harmful effects that might occur from past or future exposures to hazardous chemicals associated with the Stauffer facility can be found in the Public Health Implications section.

6. I have a friend who lived at Holiday Estates and wants to know if her miscarriage could have been caused by exposure to chemicals from Stauffer?

ATSDR Response: The most likely way residents of Holiday Springs could have been exposed to contaminants from Stauffer is by breathing polluted air coming from the facility. From the information we have about contaminants in air (particulate matter, sulfur dioxide, fluoride) coming from the site, those contaminants are not known to cause miscarriages. Whether or not other chemicals could have been released by Stauffer that might cause miscarriages is unknown.

7. Can residents eat fish from the Anclote Pier? Could past releases of fluoride contaminate fish today?

ATSDR Response: ATSDR has reviewed the environmental data from the Stauffer facility and none of the chemicals present at the site are at levels that might contaminate fish for human consumption, including fluoride.

However, FDOH issued a health advisory related to eating fish from the Anclote River in Pasco and Pinellas County because of mercury contamination. The advisory is not

related to the Stauffer site. FDOH advises that adults should limit fish consumption to one meal per week. It also advises that children under 15 years of age and nursing or pregnant women should limit consumption to one meal per month. Fish included in this advisory are largemouth bass, bowfin, and gar. Therefore, ATSDR suggests that people who fish from the Anclote Pier should follow FDOH recommendations in its fish advisory.

FDOH has information about all Florida fish consumption advisories (FDOH no date), and includes more information on the work of FDOH, FFWC, and the FDEP with regard to mercury in freshwater fish around the state. More information can be found at this website: <http://floridafisheries.com/health.html>.

8. Are there any medical problems with residents who lived near Stauffer during the years of operations and what are those problems?

ATSDR Response: The ATSDR Ombudsman report about the Stauffer facility (ATSDR 2000a) recounts several incidents by local residents who reported health problems (for example, coughing and sneezing) because of migrating plumes from the facility. Although medical problems have been reported by people who lived around the former Stauffer facility, it is not possible to determine whether or not those problems resulted from the Stauffer facility. It is possible to evaluate past exposure and decide if medical problems could have resulted from past exposure to those contaminants in air migrating from the Stauffer facility. Exposure to sulfur dioxide and particulate matter could have caused harmful effects to the heart and lung (that is, cardiovascular disease) in some residents who lived close to the facility. These effects are discussed in more detail in the Public Health Implications and Conclusions sections of this report.

9. What is the solubility of arsenic and how does its solubility affect toxicity levels with regard to drinking water wells and ground water supplies?

ATSDR Response: The solubility of arsenic depends on its chemical form. Arsenic in water tends to have high solubility, which means that when people drink water with arsenic, much of the arsenic will get into their system. Arsenic in soil, on the other hand, tends to be less soluble compared with arsenic in drinking water and tends to be less well absorbed compared with arsenic in drinking water.

10. What is the health hazard of arsenic in the soil?

ATSDR Response: If arsenic levels in soil are high enough, ingestion of arsenic from hand-to-mouth activity might increase the risk of cancer should that exposure continue for several decades. The Stauffer facility contains arsenic in pond soil that is a concern for an increased risk of cancer should that portion of the site be developed as residences. The cancers of concern are skin cancer and certain internal cancers,

including cancer of the lung, bladder, kidney, and liver. It is unlikely that levels are high enough in soil to cause other harmful effects. The hazards of arsenic in soil are discussed in more detail in the Public Health Implications section.

11. Is fluoride in the slag bioavailable and how could it affect a child with pica behavior?

ATSDR Response: At this time, it is not known whether fluoride in slag can be absorbed across the gut into the human body (that is, bioavailable). This can only be determined by feeding slag to animals, for instance young pigs, and measuring its absorption. Because these studies are expensive, ATSDR usually assumes that chemicals are bioavailable. It seems reasonable to assume that some of the fluoride would be available to cross the human gut should a person swallow slag.

For those who might not know, pica behavior is the consumption of non food items. ATSDR is particularly interested in children who eat large amounts of soil and refers to these children as having soil-pica behavior: this term distinguishes them from other types of pica behavior, for instance, eating paint chips. Probably somewhere between 4 and 20 of every 100 children (or 4% to 20%) will experience soil-pica behavior sometime during their preschool years. Soil-pica behavior occurs mostly frequently in 1- and 2-year-old children, and gradually decreases in older preschool children. Soil-pica behavior can occur just one time or it might occur several times a week. Children with soil-pica behavior can eat up to a teaspoon or more of soil, so it is possible to estimate how much of chemical a child might ingest should he or she eat soil from a contaminated area. Whether or not children would be tempted to eat slag is uncertain. Slag has the consistency of rock, not soil, so it might be unappealing to children with pica behavior. On the other hand, some children with pica behavior might be tempted to put slag in their mouth but not actually eat it.

Analytical measurements of fluoride content in slag showed that fluoride levels ranged from 30 to 1,920 ppm. Because of the uncertainty in how much fluoride is bioavailable (that is, will cross the gut if someone swallows slag), it is difficult to estimate a dose that can be used to decide if harmful effects might occur in children with soil-pica behavior. If one assumes that all the fluoride in slag crosses the gut, then for slag with 30 ppm fluorides, the dose for a 1-year-old child with soil-pica behavior is estimated as 0.01 mg/kg/day, whereas slag with 1,920 ppm fluorides will have an estimated dose of 1 mg/kg/day. These estimates are for a child eating soil one time. If a child has habitual soil-pica behavior, he or she could eat slag three times a week. The estimated dose in this case is 0.004 mg/kg/day for slag with 30 ppm fluorides and 0.4 mg/kg/day for slag with 1,920 ppm fluorides.

At 30 ppm fluorides in slag, a preschool child with soil-pica behavior is not likely to get sick from fluorides. At 1,920 ppm fluorides in slag, the estimated one-time dose of 1 mg/kg/day is too close to doses that caused harmful effects in animals to be safe. The

lethal dose in children is 16 mg/kg/day from a one-time exposure. The estimated dose of 0.4 mg/kg/day for a child with habitual soil-pica behavior is also too close to doses in animal studies that cause harmful effects. A dose of 0.5 mg/kg/day in rats for 2 months affects their endocrine system by decreasing levels of the hormone thyroxine. A dose of 0.8 mg/kg/day in mice for 4 weeks has shown damage to the bone in the form of increased bone formation and a small decrease in bone calcium levels.

It is important to remember, however, that some uncertainty exists in actually deciding whether children with soil-pica behavior might actually get sick from fluorides should they eat slag because it is not known how much of the slag will be digested to release fluorides. It also seems unlikely that children would actually eat slag.

12. Why is water from shallow water wells unfit to drink, water plants, or use for filling pools for children?

ATSDR Response: Table 7 in Appendix B shows contaminant levels in the shallow aquifer from which some wells draw their water. Groundwater from the shallow aquifer has elevated levels of several metals (arsenic, cadmium, lead, and thallium), which make it unfit to drink. Because children swallow small amounts of water while swimming, this water should also be avoided for filling pools. The water is safe for watering plants.

7.2. Environmental Concerns

1. Will air dispersion modeling be done as part of the past air emissions evaluation?

ATSDR Response: Yes (see the Air Contamination section).

2. Will the public health assessment conduct a thorough evaluation of asbestos? What data are available for asbestos in the Stauffer plant?

ATSDR Response: Asbestos sampling data are discussed and evaluated in the public health assessment.

3. Will ATSDR evaluate the original 32 contaminants of concern?

ATSDR Response: ATSDR evaluated all contaminants found at levels exceeding ATSDR health-based CVs.

4. How can people avoid current exposure to site contaminants?

ATSDR Response: People are not likely to be exposed to contaminants from the site at levels of health concern.

5. Could residents have their well water tested for safety?

ATSDR Response: Yes. If they have concerns about their private well water, Pinellas County residents can contact Ms. Bonnie Bergen at the Pinellas County Health Department and Pasco County residents can contact the Pasco County Health Department.

6. During Stauffer's operations thick, clouds of ground-level dust were emitted from the plant. What might have been contained in the dust?

ATSDR Response: Available sampling data are not adequate to allow ATSDR to determine all of the contaminants in Stauffer's air releases. However, ATSDR's review of available data shows the emissions likely contained a number of contaminants including phosphorus pentoxide, fluorides, sulfur dioxide, metals, and radionuclides.

7. Can ATSDR evaluate likely exposures to families who lived close to the Stauffer facility while it was in operation?

ATSDR Response: ATSDR's public health assessment includes evaluation of exposure of residents who lived near the Stauffer plant to airborne releases from the Stauffer facility.

8. Has ATSDR evaluated runoff water from ditches and culverts from the site into the Anclote River?

ATSDR Response: Yes. Contaminants in surface water runoff are evaluated in the sections of the public health assessment dealing with Anclote River surface water and sediment.

7.3. Radiation Concerns

1. What are the health effects of multiple radiation exposures and potential cumulative effects?

ATSDR Response: The potential for multiple radiation exposures posing an increased risk for adverse health effects depends on four things:

- ▶ the exposure level or dose,
- ▶ the type of radiation,
- ▶ the exposure pathway (external or internal), and
- ▶ the time between exposures.

When a person is repeatedly exposed to radiation, it can cause cumulative effects (also known as additive effects) to his or her body. These are effects that build up over time.

The main adverse effect of radiation to the human body is damage to the DNA, the genetic recipe for a cell. Minor damage to DNA can be repaired. However, the damage also can be serious enough to cause cell death. Between these two extremes, a mutation, or permanent change in the DNA, can occur. The change is the result of a DNA repair that has gone wrong. This is called incorrect repair. Mutations can be passed on to offspring. These changes in the DNA might not kill someone, but mutations might build up in cells. This buildup can increase the chance the person might become ill. Cell mutations in the human body have been linked to an increased risk for cancer. Mutations in reproductive cells might also occur; this type of mutation has been linked to heritable disease, which can be passed on from parents to offspring. The chance for this type of mutation increases with each exposure to radiation.

Because cancer cells divide more rapidly and are more sensitive to radiation than are healthy cells, radiation is used to treat cancer. Other rapidly growing cells that are likely to react to radiation are the cells that make blood and skin. Cells in the stomach, intestines, eyes, ovaries, and testes are also more likely to be affected by radiation than are other cells.

Cells can repair damage caused by radiation. However, being exposed to radiation time and time again before the body can repair itself might result in more damage. Effects can build up and can increase the chance for illness. Doses necessary to overwhelm repair are orders of magnitude higher than those found at the Stauffer site.

2. What are the health effects of radon?

ATSDR Response: Radon is a colorless and odorless radioactive gas that is and always has been a natural component of the air we breathe. Radon is produced by the radioactive decay of radium, a naturally occurring radioactive element found in trace amounts in all soils as well as in building materials, plants, animals, and the human body. Although scientists have been aware of radon for many years, it was not until recently that it was realized that the largest radiation exposures received by most persons comes from natural sources of radiation, primarily radon and its radioactive decay products. Radon decay products increase the risk of lung cancer, primarily among active tobacco smokers. Limited data exist to suggest that radon might increase the risk of lung cancer among nonsmokers.

3. Has ATSDR evaluated radium-226 in the private wells in the Tarpon Springs area?

ATSDR Response: The Pinellas and Pasco County Health Departments have done some limited sampling of selected drinking water wells within about a 1/4-mile radius of the site. The analysis included three radionuclides: gross alpha, radium-226, and radium-228. Sampling of these wells is ongoing on a quarterly basis, data analysis is being compiled, and trends are being evaluated.

4. Why is off-site slag not considered a public health concern while on-site slag is considered a concern?

ATSDR Response: In regards to the relative health hazards from on-site vs. off-site slag, the main issue is the gamma radiation dose rate that a person would receive from the slag. This dose rate is related to the amount of radiation emitted from the slag which is a function of the concentration of radium in the slag (pCi/kg) and the amount of slag present in a given area (kg/m²). Since there is much more slag on-site than off-site, and the on-site slag is confined to a relatively small area, the total amount of radioactivity emitted is much higher on-site than off-site. The result is that on-site gamma dose rates are orders of magnitude higher than off-site.

5. Can ATSDR ask EPA to identify the off-site slag?

ATSDR Response: Without testing every home and piece of land in the community, it cannot be said that no one is being exposed to radiation from the slag at levels above the guidelines. However, the FDOH's Bureau of Radiation Control performed many surveys and tests on the slag throughout the Tarpon Springs/Holiday area. The results assured ATSDR that the outdoor areas of slag (in roads and driveways) are not a health hazard. The slag varies little from place to place. Also, slag found in building materials of homes showed only a few areas that are near levels of any concern. The bureau will survey homes for radiation on request. Call the Environmental Laboratory in Orlando at 407-297-2095. Private consultants can also be called to do surveys.

6. How much radium is on-site?

ATSDR Response: Nearly 100 times the concentration found off-site.

7. Can ATSDR use whole-body testing to measure the total radiation body burden of former workers and area residents?

ATSDR Response: Yes, but ATSDR believes that it would not be appropriate. A total body burden test measures levels of radioactive material inside the body. The levels of radioactivity are measured using external detectors or by analyzing biological samples, such as urine or blood.

It is rare that a person will be exposed to radioactive materials at levels that require a total body burden test. This test can be used when radioactive material has entered someone's body by inhalation, ingestion, or when it enters the body through the skin or by other means. A body burden test is not a way to measure radiation exposure from sources outside the body. The test is not appropriate after external exposure to x-ray or gamma radiation. After such exposures, no radiation remains in the body. However,

although radiation does not remain in the body after an exposure, effects from the radiation exposure might remain.

This test might not be one a general practice physician would know about. However, if someone has been exposed to excessive amounts of radioactive materials from occupational exposure, a doctor can refer a patient to a specialist for such a test.

8. Previous radiation evaluations did not include information about exposure to radionuclides by inhalation and ingestion and their possible health effects. Will inhalation and ingestion be considered in future evaluations?

ATSDR Response: These exposures were considered in the August 1999 Public Health Assessment Addendum for Stauffer Chemical Company (ATSDR 1999e) and in the July 2002 Health Consultation Concerning Individual Dose Measurements In and Around Tarpon Springs, Florida (ATSDR 2002).

7.4. Community Involvement Concerns

1. Can ATSDR provide a time line of ATSDR's site activities?

ATSDR Response: After consulting with the N-2-N Committee, ATSDR has begun to (a) post our projected time line in the ATSDR Community Update/Newsletter to keep residents informed, and (b) coordinate with the Tarpon Springs Public Works Department to use billing statements to share information with residents.

2. Can ATSDR provide information on its products and services in Greek?

ATSDR Response: The majority of ATSDR's products and services (i.e., documents, fact sheets, etc.) are produced in English and some in Spanish. However, based on community needs, documents can be translated into other languages. At the Tarpon Springs site, ATSDR raised this issue with the Neighbor to Neighbor (N-2-N) group. The N-2-N members indicated that the majority of residents in Tarpon Springs and surrounding areas use English as their primary language and that it was not necessary for ATSDR to translate its documents for the Stauffer site into Greek. However, ATSDR will consider requests to provide site documents in Greek on a case-by-case basis.

7.5. Health Education Concerns

1. Can ATSDR provide environmental health education to the medical community treating people with environmental/industrial exposure?

ATSDR Response: Yes. ATSDR staff is developing environmental education packets for health care providers.

2. Can ATSDR provide education in schools with distribution of fact sheet specifically for children and a presentation at schools for parents/PTO meeting, or both?

ATSDR Response: ATSDR has provided and will continue to provide environmental health education materials to the local schools and library repositories. We will continue to provide updated information on site-related information through our Neighbor-2-Neighbor newsletter, fact sheets and formal and informal public meetings

3. Can ATSDR provide health education to former Stauffer workers?

ATSDR Response: ATSDR can provide health education to former Stauffer workers in consultation with partnering occupational health agencies

4. Will ATSDR consider doing a “health day” at Gulfside Elementary, in conjunction with the local health department, to educate students and their parents about Stauffer?

ATSDR Response: ATSDR will accept invitations from community-sponsored health events including local schools. We will provide environmental health education materials to address site-specific health concerns, including those that are specific to children.

7.6. Health Studies Concerns

1. Will ATSDR release the names of the former Stauffer Chemical Company workers and cause of death for the 700 deceased workers?

ATSDR Response: ATSDR does not release individual information because of privacy and confidentiality. The information about the former Stauffer Chemical Company workers, including cause of death, will be released as aggregate data only.

2. Why is ATSDR not conducting a health study of former Stauffer workers?

ATSDR Response: In response to community concerns and because former Stauffer workers may have been occupationally exposed to asbestos or other contaminants at levels that could cause adverse health effects, ATSDR’s Division of Health Studies

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evaluated the feasibility of conducting a health study of former Stauffer workers. Based on the results of this evaluation, ATSDR has determined that a scientific health study of former Stauffer workers is not feasible. Information used to make this determination included ATSDR's (1) evaluation of available worker exposure data, cause of death data for deceased former workers, and State of Florida cancer registry data; (2) review of previous health studies for Florida phosphate industry workers; (3) consideration of comments received from outside experts as part of ATSDR's external peer review process; and (4) consultation with scientists from CDC's National Institute for Occupational Safety and Health (NIOSH).

3. Will ATSDR release the names of former Gulfside Elementary students who attended the school during the time of the plant operations?

ATSDR Response: ATSDR does not release information on individuals because of privacy and confidentiality issues. Information about the former Gulfside Elementary students will be released as aggregate data only.

4. How do we get NIOSH involved?

ATSDR Response: ATSDR consulted with NIOSH's Hazard Evaluations and Technical Assistance Branch regarding the feasibility of conducting a health study of former Stauffer workers. Based on their review of the Stauffer public health assessment and the results of two previous health studies of Florida phosphate workers, NIOSH concluded that it would not be feasible to conduct a meaningful health study of former Stauffer workers. ATSDR will continue to seek input and guidance from NIOSH regarding other possible health activities (e.g., focused health/medical screening) for former Stauffer workers.

8. HEALTH OUTCOME DATA EVALUATION

8.1. Health Statistics Review of Populations Living Near Stauffer

8.1.1. Background

At the request of ATSDR, the Florida Department of Health (FDOH) conducted a cancer incidence analysis of populations living near the Stauffer Chemical Company (Stauffer) site. ATSDR made the request on behalf of concerned citizens who perceived there to be an excess of cancer and other illnesses among citizens who live(d) near the Stauffer facility. Therefore, based on the substances and radioactive matter that were utilized at the site during the years of operation, ATSDR and the University of South Florida staff selected specific cancer types for analysis. These cancers were chosen because they represent groupings that are associated with substances used at the site and because some cancers may be more sensitive to the effects of radiation. The cancers analyzed included: bone, brain, leukemia, lung and bronchus, lymphomas, melanoma, mesothelioma, and thyroid cancers.

8.1.2. Methods

The target area consisted of four combined census tracts: the census tract where the Stauffer facility was located (103027308) and three surrounding, adjacent census tracts (101030400, 103027501, and 103027401). The period analyzed consisted of three five year time periods: 1985-1989, 1990-1994, and 1995-1999. These were chosen because they represent all of the years of data available from the Florida Cancer Data System (FCDS). The population analyzed consisted of those residents who lived within the combined census tracts during 1985-1999. Standardized incidence ratios (SIRs) were calculated for the eight site-specific cancers mentioned above by sex and time period. SIRs are the observed number of specified cancer cases for the residents of the target area divided by the expected number of cancer cases for the population of the target area, assuming the rate was the same as elsewhere in Florida. An SIR of exactly one indicates that the target area's incidence is equal to what is expected. An SIR less than one indicates that the target area's incidence is lower than what is expected. An SIR greater than one indicates that the target area's incidence is higher than what is expected. Expected numbers were calculated using average state incidence rates for whites from 1985 to 1999. The rates of whites in Florida were used because there were fewer than one percent of blacks living in the target area during the time period analyzed. For the state of Florida and county populations, official intercensal estimates were generated by the governor's office, while the intercensal target area population was estimated by linear extrapolation from the U.S. census data for Florida. Significance tests—p-values and 95% confidence intervals—were also used to determine whether the generated SIRs were statistically significant.

8.1.3. Results

For the time period 1985-1989, all of the SIRs were less than what would be expected for the target area, many of which were statistically significantly lower. The most likely explanation for this was that the FCDS was just getting established in the early 1980s, possibly resulting in an under reporting of cases to the registry for the time period 1985-1989. For this reason, it was decided by ATSDR and FDOH to focus on the cancer incidence for the combined years 1990-1999, and also separately for 1990-1994 and 1995-1999. For the combined years of 1990-1999, the SIRs for all cancers examined were less than or equal to what one would have expected to see for the target area. However, when examining the time periods of 1990-1994 and 1995-1999 separately, mesothelioma in women was found to be significantly elevated during 1990-1994 (3 cases observed, 0.6 cases expected; SIR=5.0; $p<0.02$). In comparison, mesothelioma in men was not significantly elevated for these same time periods (4 cases observed, 3.1 cases expected, SIR=1.3, $p<0.28$; and 1 case observed, 3 cases expected, SIR=0.3; respectively).

8.1.4. Discussion and Recommendations

Mesothelioma, a rare form of cancer, is a disease in which cancer cells are found in the sac lining the chest or abdomen. Mesothelioma has a long latency period—usually 30 to 40 years—yet is almost always fatal by the time it is diagnosed. Mesothelioma occurs predominately in men and is usually acquired through an occupational exposure to asbestos (e.g., ship-building). What is unusual about the significant elevation found in the target area is that the excess occurred in women. This finding could be the result of an occupational exposure that occurred decades ago from a nearby facility(s) that used asbestos. Another possibility for this excess could be due to take-home exposure from asbestos-contaminated clothing from husbands who worked in a facility(s) that used asbestos. It is also possible that this excess could be due to a community exposure via ambient air from a nearby facility(s) that used asbestos; however, given that the excess appears to be limited to females only, this possibility is not likely.

In response to this excess of disease, further exploration of these three mesothelioma cases was conducted by ATSDR and the FDOH to determine how the individuals might have possibly been exposed. ATSDR requested—and received—select information on these three individuals from the FCDS for verification. The information requested included name, sex, date of birth, diagnosis date, age at diagnosis, occupational industry, and address at diagnosis in order to determine if these individuals were Stauffer workers or spouses of workers. ATSDR cross-referenced these three individuals with a worker list that was provided by Stauffer to identify a possible exposure relationship. ATSDR was not able to identify these names on the list of former workers. Therefore, we do not think that these women or their spouses were Stauffer workers. To gain supplemental occupational information not otherwise know, ATSDR reviewed the death certificates for these three women. The occupational status listed on these death certificates was either blank or coded simply as “retired.” Given that Florida is a large retirements state, it is possible that these three women were exposed to asbestos elsewhere. To investigate the time frame that these three women lived in the site area, ATSDR retrieved information from public

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deed records. The deed records indicated that the three women moved into the site area between 1968 and 1979; two of the women were 60 years old and the other was 55 years old when they bought their homes. The three women lived at their residences for a total of 15 to 26 years prior to their deaths, and more significantly, 3 to 13 years while the Stauffer facility was in operation. As such, ATSDR believes that the three women were likely exposed to asbestos prior to moving to the Tarpon Springs area for retirement, and, therefore, the three asbestos cases are not related to the Stauffer site.

For public health surveillance and health information purposes, ATSDR recommends that the FDOH continue to monitor the area for the annual incidence of mesothelioma and lung cancer.

9. CONCLUSIONS

9.1. Current Site Conditions and Exposures

The Stauffer Chemical Company site is currently not a public health threat because people are not being exposed to contaminants from the site at unsafe levels.

9.1.1. Current Air Exposures

The levels of TSP, PM₁₀, and PM_{2.5} were reduced after 1981 when the Stauffer plant stopped operating. Since 1981, the estimated and measured levels of particulate matter in the general vicinity of the former Stauffer plant, and subsequent risk of an adverse heart and lung health outcome, were similar to those in many areas of Florida and the United States.

Current levels of sulfur dioxide in air are not likely to cause harmful effects in people, including people with asthma.

Results of air sampling conducted by EPA in the 1990s for fluorides show it is unlikely that fluoride is being released to the air at harmful levels.

9.1.2. Other Current Exposures

The concentrations of radionuclides measured at Gulfside Elementary School do not pose a health hazard to students or staff.

9.2. Past Site Conditions and Exposures

9.2.1. Historical (Past) Air Exposures Before 1982

Levels of air pollution in the immediate area of the Stauffer facility while it was operating were likely to be a public health hazard because of the combined emissions from the Stauffer facility and from other sources in the area. The components of air pollution causing the health hazard are sulfur dioxide and particulate matter. These components reached levels that in the scientific literature were associated with an increased incidence of adverse lung and heart conditions. Populations at greatest risk for suffering adverse health effects include children, the elderly, persons with preexisting heart or lung disease, and persons with asthma who lived or worked near the Stauffer facility. In making this hazard determination, some uncertainty exists in the health conclusions for long- and short-term exposures to particulate matter and long-term exposure to sulfur dioxide. However, both sulfur dioxide, as well as particulate matter, are likely to effect the lungs; therefore, any added particulate matter exposures in combination with sulfur dioxide exposures may have increased the risk of an adverse effect to the lungs. Specific perspective on the public health implications of exposure and uncertainty of exposures to sulfur dioxide and particulate matter follow.

9.2.1.1. Short-term and long-term exposure to particulate matter

Particulate matter is ubiquitous both in outdoor and indoor environments. Besides the multiple outdoor sources of PM exposures to the community (including the Stauffer facility, the Florida Power Anclote Plant, automobiles, and others), there are numerous other indoor sources of PM exposures from cooking, cleaning, and other indoor activities. The sampling data quite clearly demonstrate that air emissions when the Stauffer facility was active caused increases in particulate matter concentrations near the facility. However, the particulate matter levels measured near Stauffer between 1977-1981, though greater than Florida's previous air quality standards, were similar to particulate matter levels routinely measured in many suburban and urban settings throughout the state. When ATSDR evaluates exposure to environmental contamination, our primary role is to examine whether exposures are at levels associated with adverse health effects. Whether or not other populations experienced greater or lesser exposures does not factor into our public health evaluations for a given site.

ATSDR relied on the vast epidemiological evidence that strongly suggests that short- and long-term exposure to particulate matter is associated with adverse lung and heart diseases. Specifically, the scientific literature has shown associations with very serious health effects (death) to less serious health effects (e.g., slight lung function changes). Based on our best estimates, particulate matter exposures from all sources and that attributable to Stauffer could have resulted in one of the adverse health effects shown in the scientific literature. Moreover, the population exposed to particulate matter attributable to Stauffer are more likely to have experienced the less serious health effects of lung and heart diseases and reductions in lung function than other more serious health effects reported in the literature. Although ATSDR provides this perspective for the community to better understand their risk of the most serious adverse health effect, we do so with some uncertainty. Given that the exposed population may have had a higher percentage of elderly (a likely sensitive population), ATSDR cannot completely rule-out any of the adverse health effects that have been associated with PM exposures. In any case, the risk of an adverse cardiopulmonary health outcome was likely reduced once the Stauffer facility ceased operation in 1981 because the levels of exposure to particulate matter, especially the smaller, fine, particles were lowered.

Persons residing in or working in the following areas might have experienced adverse health effects similar to those reported in the literature from their exposures to particulate matter:

- The Flaherty Marina (before 1982),
- Residential homes built before 1982 southwest of the Stauffer facility along the shore of the Anclote River,
- Residential homes west of the Stauffer facility built before 1982 and within 1,540 feet of the kiln, and
- Commercial and industrial businesses east of the Stauffer facility along Anclote Road built before 1982 and within 1,540 feet of the kiln.

9.2.1.2 Short-term and long-term exposure to sulfur dioxide

Air monitoring data are available for 1977 to 1979 and most of the time sulfur dioxide levels were below ATSDR's health guideline of 10 parts per billion (ppb). Periodically, however, hourly sulfur dioxide levels at the Anclothe Road monitoring station near the Flaherty Marina showed significantly elevated levels of sulfur dioxide. The highest average sulfur dioxide level detected in a one- hour monitoring period was 840 parts per billion (ppb). Because valid human studies are available concerning the harmful effects of sulfur dioxide, ATSDR is concerned about the times when sulfur dioxide levels were above 100 ppb, the lowest known level to cause a response in humans. The concern becomes greater at levels above 500 ppb.

People who lived, worked, or visited the following areas before 1981 when Stauffer was operating were at risk for harmful effects from exposure to sulfur dioxide based on hourly measurements.

These areas include:

- The Flaherty Marina,
- Residential homes southwest of the Stauffer facility along the shore of the Anclothe River,
- Residential homes west of the Stauffer facility, and
- Commercial and industrial businesses east of the Stauffer facility along Anclothe Road.

People who lived in these areas might have experienced the following harmful effects:

- changes in lung function (such as, an increase in airway resistance and a narrowing of lung's airways,
- wheezing and shortness of breath,
- an increase in heart rate and breathing rate,
- cough, and
- throat irritation.

It is important to remember that people who are most sensitive to the effects of sulfur dioxide are people with asthma who were exercising while being exposed to sulfur dioxide. Only at the higher hourly levels detected (600 to 800 ppb) will healthy (non-asthmatic) people experience some of the symptoms of sulfur dioxide exposure.

ATSDR used an air dispersion model to predict sulfur dioxide levels in the surrounding community for times when Stauffer had a major release of sulfur dioxide. This model predicted that significant sulfur dioxide levels moved into the surrounding community.

It is important to remember that exposure to relatively low levels of sulfur dioxide (for example, 100 ppb sulfur dioxide) is not likely to cause noticeable symptoms, such as wheezing or shortness of breath. At 100 ppb sulfur dioxide, only exercising asthmatics have shown responses and these responses were mild changes in the lung's airways (specifically, an increase in airway resistance). It should also be pointed out that the human studies conducted at 100 ppb had asthmatics breathe through a mouthpiece, thus increasing their exposure to sulfur dioxide. It is uncertain if

exercising asthmatics would experience these mild effects on the lungs if they were exercising and breathing through their mouth and nose. It is also important to know that this increase in airway resistance is temporary and will return to normal shortly after exposure ends. However, as sulfur dioxide levels exceed 500 ppb, some asthmatics will require medication to treat the symptoms of wheezing and shortness of breath.

Results of air monitoring at the Anclote Road monitoring station and the air dispersion model showed that residents who lived in portions of Tarpon Springs, Holiday Estates, and surrounding areas were likely exposed for many years to elevated yearly sulfur dioxide levels. The sulfur dioxide levels are similar to levels shown in human studies to be associated with a small increase in mortality, particularly in people with pre-existing lung and heart disease. The increased risk of mortality existed while people were being exposed. Because of the low levels of exposure from 1977 to 1981, it is unlikely that people who were exposed in the past are currently at risk of harmful effects. The areas most impacted by Stauffer emissions are shown in Figure 27 and include the areas covered by the 10 ppb and 5 ppb contours. Some uncertainty exists in these conclusions because the results are based on modeling information and some uncertainty exists in the human studies.

9.2.1.3. Exposure to hydrogen fluoride

The limited number of air samples that measured for fluoride did not show fluoride to be a health concern. However, one of the historical air samples showed fluoride levels at Stauffer's fence line to be slightly above ATSDR's acute Minimal Risk Level (MRL). Irritant effects from brief exposures to the fluoride level detected seem unlikely because the detected fluoride level was far below the level that caused harmful effects. Firm conclusions, however, cannot be drawn because the sample averaged fluoride levels over 24 hours, which might have masked higher levels of fluoride in a migrating plume. In addition, too few air samples were taken for fluorides when the Stauffer facility was operating to determine what levels of fluorides were being released. ATSDR's modeling analysis, which was based on the best available emissions data, suggests that ambient air concentrations of fluorides did not exceed levels of health concern. Although this modeling analysis has limitations (most notably that emissions data were not available for every source at the facility), ATSDR is reassured by its previous evaluations of air quality issues at much larger elemental phosphorus production facilities, with very extensive air sampling data for fluorides, which showed no evidence of fluoride exposures at levels of health concern.

9.2.1.4. Exposure to Other Air Pollutants

Residents who lived near the Stauffer facility while it was operating were likely exposed to a number of additional contaminants in air (e.g., metals, phosphorus compounds, inorganic acids); however, the magnitude and impact of these exposures could not be evaluated from available site data and information.

9.2.1.5. Uncertainty in Health Conclusions About Air Pollutants

Some uncertainty exists in ATSDR's health conclusions, such as

- The accuracy of the estimated levels of PM_{2.5} for the 1970s and 1980s. Using the limited TSP data from 1977-1981, ATSDR developed our best estimate of what exposures to fine particulates may have been. The methods used and justifications for developing these estimates are provided by ATSDR in the public health assessment.
- Some scientists believe that the associations found in epidemiological studies do not provide conclusive evidence that exposure to ambient levels of particulate matter and sulfur dioxide actually cause adverse cardiopulmonary health effects because a clear biological mechanism, among other things, has yet to be clearly established. While ATSDR acknowledges this uncertainty, based on the strong epidemiological evidence, we feel that a number of health effects were possible because of past exposures to Stauffer particulate matter and sulfur dioxide emissions.
- Some studies suggest that certain types of particulate matter may be more or less toxic depending on the size of the particles and the composition. ATSDR has no information to conclude that the particulate matter emitted from Stauffer was any more or less toxic than particulate matter that has been associated with adverse cardiopulmonary health effects in the scientific literature.
- The overall interpretation of the scientific inquiry into the health effects of particulate matter and sulfur dioxide. For example, some suggest that particulate matter and sulfur dioxide can be viewed as a surrogate indicator for the overall mixture of air contaminants, as a specific cause of health effects, or both. **Whatever the case, in general, ATSDR believes that reducing particulate matter and sulfur dioxide exposure would be expected to lead to reducing the frequency and severity of the health effects associated with exposure to particulate matter and sulfur dioxide.**
- The levels of particulate matter that are considered protective for all segments of the population. ATSDR's evaluation of the public health implications of exposures to particulate matter incorporates the understanding that no currently established "safe" levels of particulate matter exposure exist.
- The effects on the lungs caused by exposure to 100 ppb sulfur dioxide occurred in subjects who breathed through a mouthpiece while exercising. Whether or not the same effects would occur in subjects who breathed through their mouth and nose while exercising is uncertain. However, this and other effects were seen in subjects exposed in a chamber to higher levels of sulfur dioxide.

9.2.1.6. Review of Community Health Concerns about Past Stauffer Air Emissions

Some of the health concerns expressed by community members in relation to past air exposures related to the Stauffer facility (i.e., asthma, breathing problems, chronic obstructive pulmonary disease [COPD], and other nonspecific lung diseases) are reasonably consistent, with adverse health outcomes reported in the epidemiologic literature for both acute and chronic exposures to particulate matter (or sulfur dioxide). For asthma, it is important to note that the scientific literature does not currently suggest that PM causes asthma but that it may exacerbate it. Moreover, there are other known and suspected factors that may trigger asthma. A list of these triggers can be found at <http://www.lungusa.org/asthma/astatrigger.html> and <http://www.lungusa.org/asthma/asctriggers.html>. The consistency between the community's health concerns and the epidemiologic studies does not suggest that a specific person's disease was caused by inhalation exposures to particulate matter. Rather, the cause of any disease is usually a result of multiple factors. For example, smoking is a strong risk factor for many lung and heart diseases. Therefore, smokers make up another population group likely at increased risk for particulate matter-related health effects (EPA 1996). ATSDR has not determined that any of these reported illnesses are elevated in the community in relation to exposures from Stauffer, but only that they are consistent with the findings from the scientific literature.

9.2.2. Contaminants in Private Drinking Water Supplies

Two commercial wells and one private well near the Stauffer facility contained arsenic at levels that exceeded EPA's drinking water standard of 10 ppb. The elevated arsenic levels are not believed to be related to groundwater contamination beneath the Stauffer site.

It is unlikely that children or adults would experience noncancerous harmful effects from drinking water from these wells. A small theoretical increase in the risk of cancer can be calculated should someone drink 8 glasses (2 liters) of water from these wells on a daily basis over a lifetime; however, the risk might also be zero. Uncertainty exists in deciding the risk of cancer because only one well sample is available; therefore, the concentration of arsenic in the well throughout someone's lifetime may vary. ATSDR's estimate of a small theoretical increase in the risk of cancer assumes a lifetime of exposure at the arsenic concentration in that one sample.

Four private wells near the Stauffer facility contained lead at levels that exceeded EPA's action level of 15 ppb. The elevated lead levels are not believed to be related to groundwater contamination beneath the Stauffer site. The highest lead level detected was 270 ppb. This level was detected only one time, which means that the people who used this well were probably only exposed for several months to lead. Lead levels 3 months before and 3 months after the high level were below EPA's action level. Brief exposures to 270 ppb lead in drinking water for a preschool child might cause changes in blood chemistry, mild effects to the liver, and, for boys, mild effects to the prostate. These effects are also likely for preschool children who used the well that contained 160 ppb lead. For the other two wells that contained 18 and 24 ppb lead, harmful effects are unlikely.

9.2.3. *Former Gulfside Elementary Students*

ATSDR determined that two primary exposure pathways could have had an impact on children who attended Gulfside Elementary school from 1978–1981. The two exposure pathways are contact with soil and breathing outdoor air.

Soil sampling at the school showed elevated levels of radionuclides; however, the concentrations of radionuclides did not pose a health hazard at the levels measured. The elevated radionuclide levels may have been associated with wind-blown dust from the Stauffer slag processing and loading operation which was located directly across the street from the school. Arsenic was also detected in soils at the school but not at levels of health concern. In addition, the amount of soil and dust that children in elementary school ingest incidentally during their daily activities is small. Therefore, adverse health effects from exposure of Gulfside Elementary students to contaminants in school soils would not be expected.

Air monitoring data showed that children could have been exposed for brief periods to high levels of sulfur dioxide on some days. However, on most days the wind came from a direction that would have blown the pollution away from the school. These intermittent exposure to high levels of sulfur dioxide might have caused the following symptoms in some children at the time of the exposure in 1978 to 1981: throat irritation, cough, wheezing, and shortness of breath. In addition to brief periods of exposure to high levels of sulfur dioxide, children who attended Gulfside Elementary School might have been exposed to sulfur dioxide for long periods. Results of air monitoring at the Anclote Road monitoring station and the air dispersion model showed that children and adults at Gulfside Elementary School were likely exposed for many years to slightly elevated yearly sulfur dioxide levels. The yearly sulfur dioxide levels are similar to levels shown in human studies to be associated with a small increase in mortality, particularly in people with pre-existing lung and heart disease. The increased risk of mortality existed while people were being exposed. Because of the low levels of exposure from 1977 to 1981, it is unlikely that people who were exposed in the past are currently at risk of harmful effects. The areas most impacted by Stauffer emissions are shown in Figure 27 and include the areas covered by the 10 ppb and 5 ppb contours. Some uncertainty exists in these conclusions because the results are based on modeling information and some uncertainty exists in the human studies.

The students at Gulfside Elementary School were probably exposed to increased levels of particulate matter (PM) while Stauffer was operating. However, the lack of good information regarding their PM exposures does not allow ATSDR to determine with any certainty if these exposures constituted a hazard. No quality air monitoring data or reliable estimates from computer modeling are available for the school. Because this information is lacking, it was not possible to accurately estimate exposure to particulate matter for children who attended the school. Therefore, it was not possible to determine if particulate matter in air was a hazard to students at the Gulfside school.

It should be noted that the risk of adverse health effects from long-term exposure to sulfur dioxide and particulate matter existed while the students and adults were being exposed. There is

uncertainty in estimating health risks for former Gulfside students because the human studies measured sulfur dioxide and particulate matter in the same year that mortality was measured; whereas, exposures at Gulfside Elementary School stopped over 20 years ago. Because of the relatively low levels of exposure from 1978 to 1981, it is unlikely that former students and adults who were exposed in the past are currently at risk of harmful effects. Therefore, ATSDR concludes that a scientific study of Gulfside former students is not appropriate at this time.

ATSDR, in collaboration with the University of South Florida, initiated and recently completed a project to determine whether the former Gulfside Elementary students could be located. The preliminary results of the project indicate that 557 (91%) of 615 former students were located. This information could be useful for future dissemination of health information and health education to former students.

9.2.4. Former Stauffer Workers

With regard to exposures of former workers at the Stauffer facility, ATSDR concludes the following:

- Former workers at Stauffer were intermittently exposed to asbestos or ACM at levels that indicate an increased theoretical risk of cancer, but it is unlikely (based on air monitoring data) that workers are at risk of asbestosis.
- Former workers at Stauffer were intermittently exposed to nickel and chromium at levels that indicate an increased theoretical risk of cancer.
- Former workers at Stauffer were intermittently exposed to carbon monoxide, chromium, hydrogen sulfide, lead, nickel, phosphorus compounds, sulfur dioxide, as well as total dust, quartz, and silica at levels that can cause adverse health effects.
- Cause of death data for deceased former workers did not indicate an elevated number of deaths due lung diseases consistent with Stauffer site contaminants, e.g., asbestos.
- Because of known and suspected past exposures for former workers, ATSDR will hold a workshop in Atlanta, Georgia, for scientific discussion and input for planning health/medical screening for Stauffer former workers. ATSDR will seek input from medical and scientific experts for the identification and risks of appropriate screening tests. ATSDR believes the screening service will provide valuable information to the former worker, his/her physician, and family.

9.2.5. Health Statistics Review

At ATSDR's request, FDOH conducted a cancer incidence analysis of populations living near Stauffer. ATSDR made the request on behalf of concerned citizens who perceived there to be an excess of cancer and other illnesses among citizens who live or lived near the Stauffer facility.

The cancers analyzed included bone, brain, leukemia, lung and bronchus, lymphomas, melanoma, mesothelioma, and thyroid cancers.

For the combined years of 1990–1999, SIRs for all cancers examined were less than or equal to what would be expected for the target area. However, when examining the time periods of 1990–1994 and 1995–1999 separately, mesothelioma in women was significantly elevated during 1990–1994 (3 cases observed, 0.6 cases expected; SIR=5.0; $p<0.02$).

ATSDR obtained information from the death certificates of the 3 women diagnosed with mesothelioma, and cross-referenced names with the Stauffer former worker list to identify a possible exposure relationship. There was no apparent relationship with the Stauffer site for these female cases (and for a spouse with the same last name). In addition, cause of death information for deceased former workers did not indicate an elevated number of deaths due lung diseases consistent with Stauffer site contaminants, e.g., asbestosis.

9.3. Future Site Conditions and Exposures

9.3.1. Radioactivity in On-Site Slag

On-site slag would pose a public health hazard if the site was developed into a residential neighborhood. Radium-226 is the principal radiologic contaminant of concern. The primary concern is that gamma radiation from the slag would result in significantly elevated radiation doses if the land was developed for residential use.

9.3.2. Contaminants in On-Site Soil

If the Stauffer facility was developed into a residential neighborhood, arsenic levels in the pond soils area would be a public health hazard. Long-term exposure over many decades could increase the risk of cancer from accidental soil ingestion from hand-to-mouth activity.

10. RECOMMENDATIONS

An important part of a public health assessment is that ATSDR makes recommendations, both to itself and to other agencies or groups, about public health actions that the agency thinks should be conducted at a hazardous waste site or in the community. In developing these recommendations, ATSDR talks to other agencies and groups to determine whether someone is available to follow up on these recommendations. The results of these discussions are presented in the Public Health Action Plan section. Following are ATSDR's recommendations for the Stauffer site.

1. Prevent exposure to radiation in the on-site slag should the site be considered for residential development.
2. Conduct follow-up activities for users of residential and commercial wells that contained elevated levels of arsenic and lead to determine whether the wells are still in use and to ensure that the users are aware of the potential risks from past use of the wells.
3. Review new site data, as they become available, for potential public health implications, including the results of the recent geophysical and hydrogeologic site investigations.
4. Provide health education to former Stauffer workers focused on healthy habits for respiratory illness care and prevention through (1) local meetings; (2) established repositories, and/or (3) mailing using available mailing lists of former workers.
5. Provide health education to local health care providers including health information related to (1) taking patients' environmental exposure histories and (2) available contaminant-specific case studies and fact sheets.
6. Continue to provide health education to area residents and people who attended Gulfside Elementary from 1978 to 1981 through distribution of (1) Neighbor-2-Neighbor community newsletters for the Stauffer site, (2) chemical-specific and exposure-related fact sheets, and (3) public health fact sheets.
7. Provide health education materials in Greek if necessary based on the needs of the Tarpon Springs community.
8. Conduct a special workshop of medical experts for the discussion, input, and guidance for possible future health activities (e.g., focused health/medical screening) for former Stauffer workers.
9. For public health surveillance and health information purposes, continue to monitor the area for the annual incidence of mesothelioma and lung cancer.

11. PUBLIC HEALTH ACTION PLAN

The public health action plan (PHAP) for the Stauffer site contains a description of actions that have been or will be taken by ATSDR and other government agencies at the site. The purpose of the PHAP is to ensure that this public health assessment not only identifies public health hazards associated with the site, but also provides a plan of action to prevent or minimize the potential for adverse human health effects from exposure to site-related hazardous substances.

11.1. Division of Health Assessment and Consultation Activities

1. ATSDR's Division of Health Assessment and Consultation, in conjunction with the Pinellas County Health Department, will conduct follow-up activities for users of residential and commercial wells that contained elevated levels of arsenic and lead. ATSDR will determine whether the wells are still in use and ensure that the users are aware of the potential risks from past use of the wells.
2. ATSDR's Division of Health Assessment and Consultation will review new site data as they become available, including the results of the recent geophysical and hydrogeologic site investigations, and modify this public health assessment if necessary.

11.2. Division of Health Education and Promotion Activities

1. ATSDR's Division of Health Education and Promotion will provide health education to former Stauffer workers focused on healthy habits for respiratory illness care and prevention through (1) local meetings; (2) established repositories, and/or (3) mailing using available mailing lists of former workers.
2. ATSDR's Division of Health Education and Promotion will provide health education to local health care providers including health information related to (1) taking patients' environmental exposure histories and (2) available contaminant-specific case studies and fact sheets. This information will be provided by mail and at local meetings, including grand rounds and/or other professional medical meetings.
3. ATSDR's Division of Health Education and Promotion will continue to provide health education to area residents and people who attended Gulfside Elementary from 1978 to 1981 through distribution of (1) Neighbor-2-Neighbor community newsletters for the Stauffer site, (2) chemical-specific and exposure-related fact sheets, and (3) public health fact sheets. These materials will be provided during local meetings, through established repositories, and/or by mail (upon request).
4. ATSDR's Division of Health Education and Promotion will consider providing health education materials in Greek upon request.

11.3. Division of Health Studies Activities

1. ATSDR Division of Health Studies will coordinate and facilitate the planning and conduct of a one-day workshop in Atlanta, GA, for the purpose of identifying appropriate follow-up health activities or screening for former Stauffer workers. Approximately 4 to 5 "environmental medicine" experts will be identified and invited to attend. ATSDR also plans to invite a former worker, who lives in the community, to attend this session and provide information about working conditions and work-related exposures, especially exposures that occurred between 1947 and 1970. A community representative and an area physician will also be invited. The workshop will be conducted according to a meeting agenda and suggested guidelines in order to optimize input by experts. ATSDR will provide a summary of the workshop to interested stakeholders. The workshop is tentatively planned for May 2003.

2. ATSDR's Division of Health Studies will work with FDOH to monitor the annual incidence of mesothelioma and lung cancer in the site area. This monitoring activity will be conducted for public health surveillance reasons and will not necessarily be focused on a particular site or group of sites. FDOH has agreed to provide an annual data report to ATSDR for addressing this surveillance activity recommendation. ATSDR will be responsible for communicating findings of annual surveillance to the community. This reporting will be a component of ATSDR's broader health communications activities with the Stauffer community.

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APPENDIX A – FIGURES

Agency for Toxic Substances and Disease Registry
Figure 1. Stauffer Chemical Company and Vicinity
Tarpon Springs, Florida

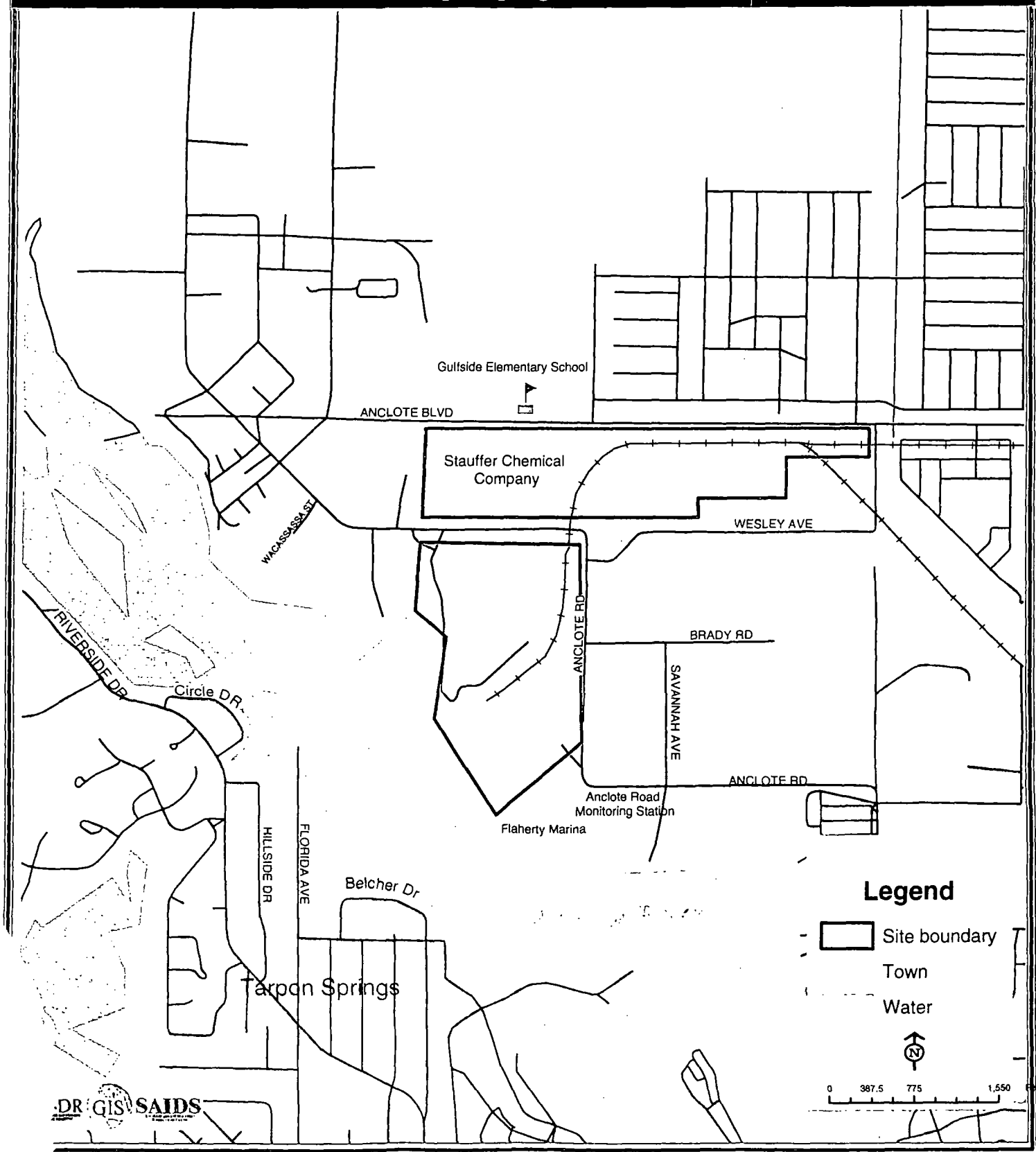
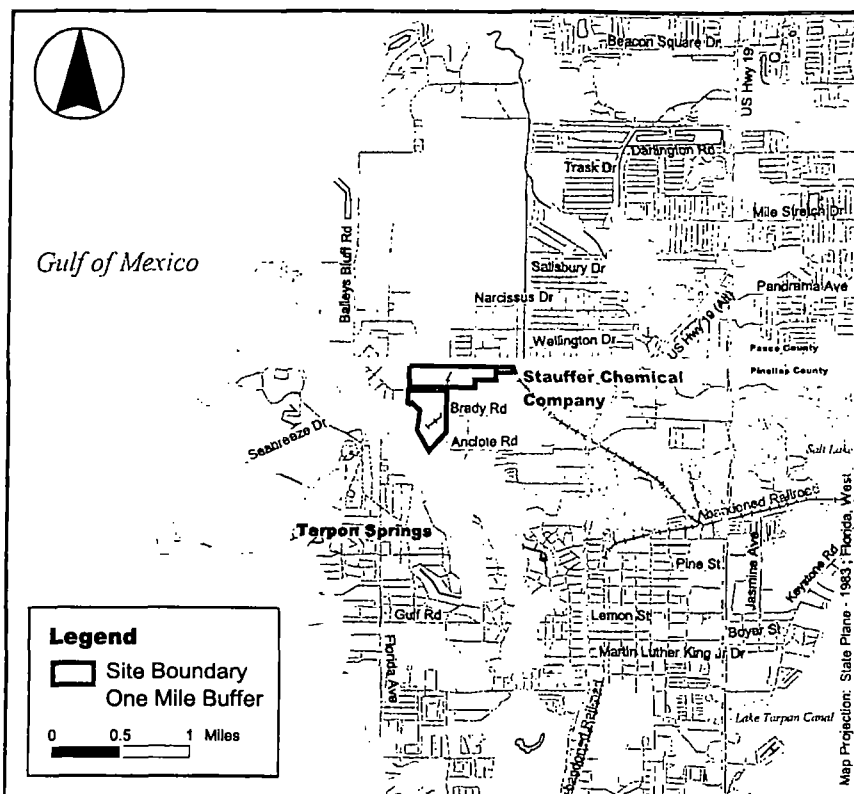


Figure 2. General Location and Demographic Information

**Stauffer Chemical Company
Tarpon Springs, Florida**



Base Map Source: 1995 TIGER/Line Files



Site Location

Pinellas and Pasco Counties, Florida

**Demographic Statistics
Within Area of Concern***

Total Population	9234
White alone	8621
Black alone	240
Am. Indian and Alaska Native alone	37
Asian alone	119
Native Hawaiian and Other Pacific Islander alone	5
Some other race alone	65
Two or More races	149
Hispanic or Latino	313
Children Aged 6 and Younger	629
Adults Aged 65 and Older	2538
Females Aged 15 - 44	1503
Total Housing Units	4677

Demographics Statistics Source: 2000 US Census
*Calculated using an area-proportion spatial analysis technique

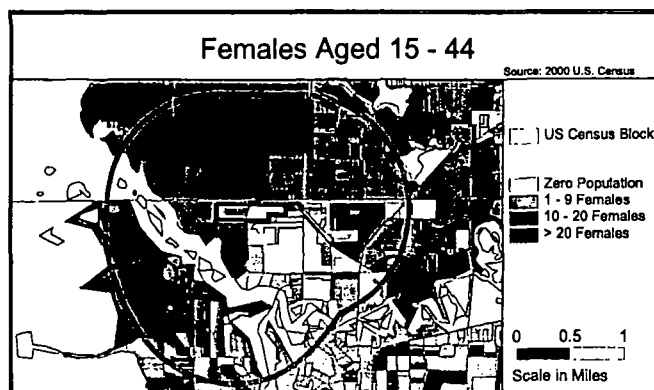
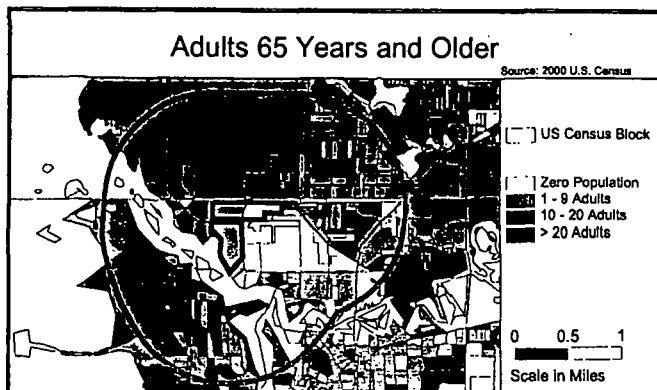
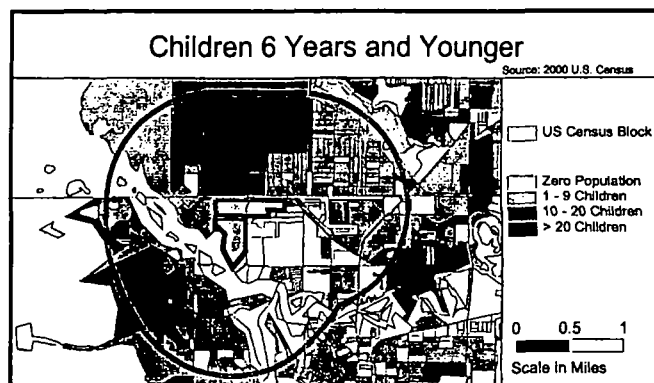
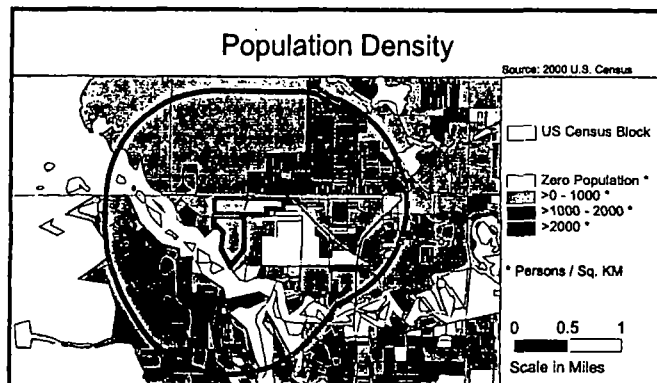


Figure 3. Private and public supply wells in the Stauffer vicinity

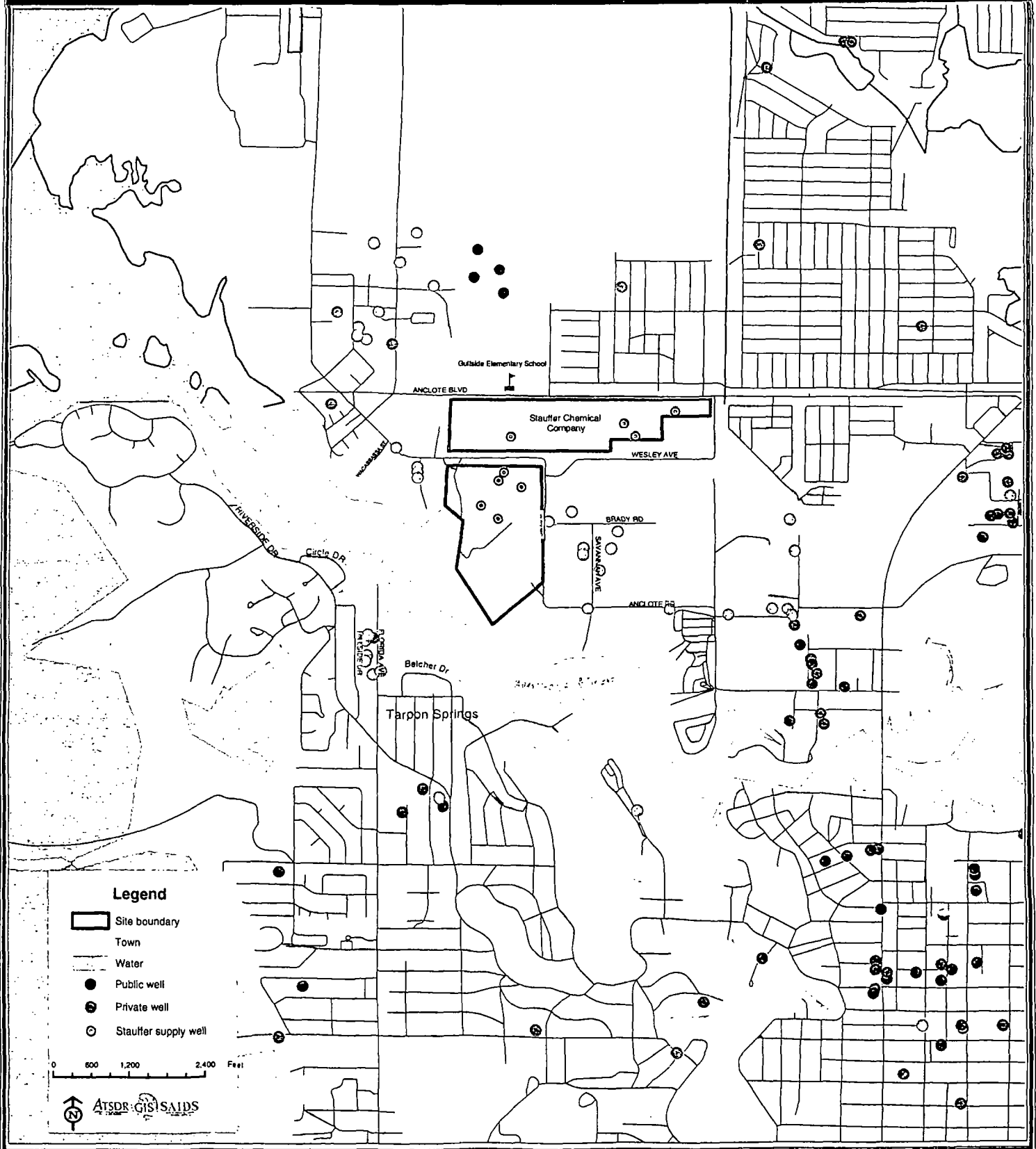
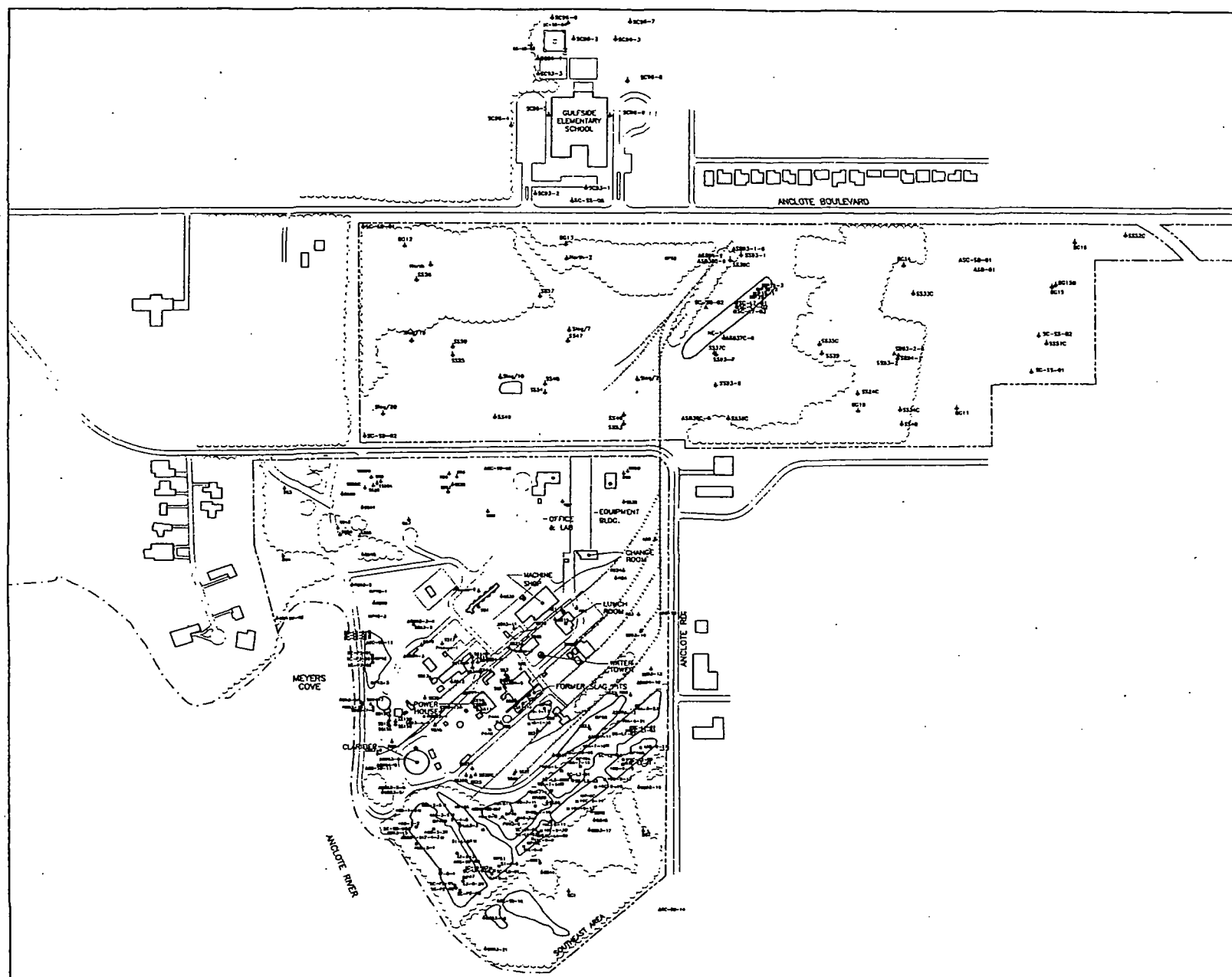


Figure 4. Soil Sampling Locations

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LEGEND

- PROPERTY BOUNDARY
- APPROXIMATE SHORELINE
- TREE LINE
- FORMER RAILROAD TRACKS

NOTE: ALL SAMPLE LOCATIONS SHOWN HERE ARE CONSIDERED APPROXIMATE ONLY

STAUFFER CHEMICAL
SUPERFUND SITE
TARPON SPRINGS, FLORIDA

SOIL SAMPLE
LOCATION PLAN

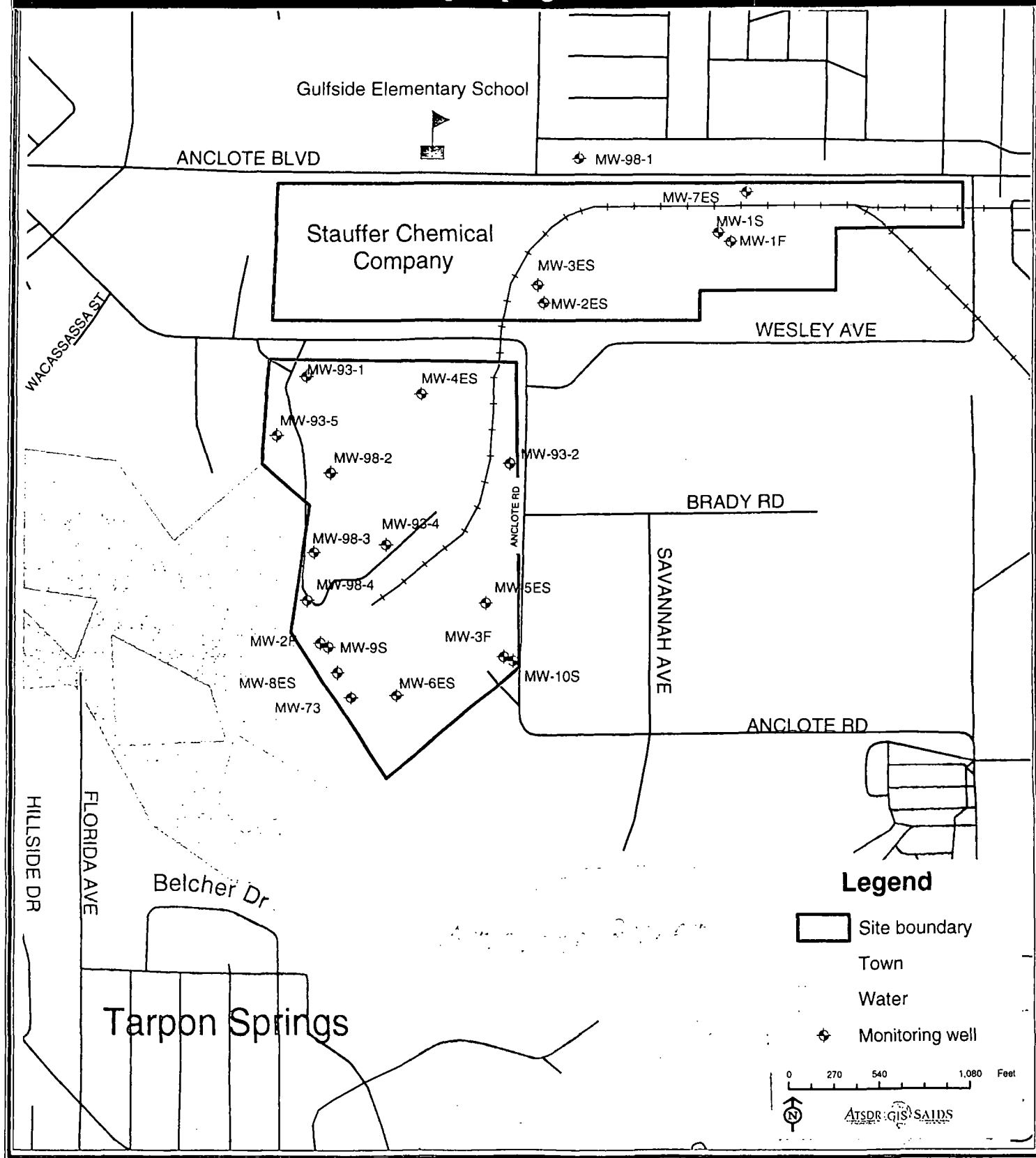
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Agency for Toxic Substances and Disease Registry
Figure 5. Stauffer monitoring well locations

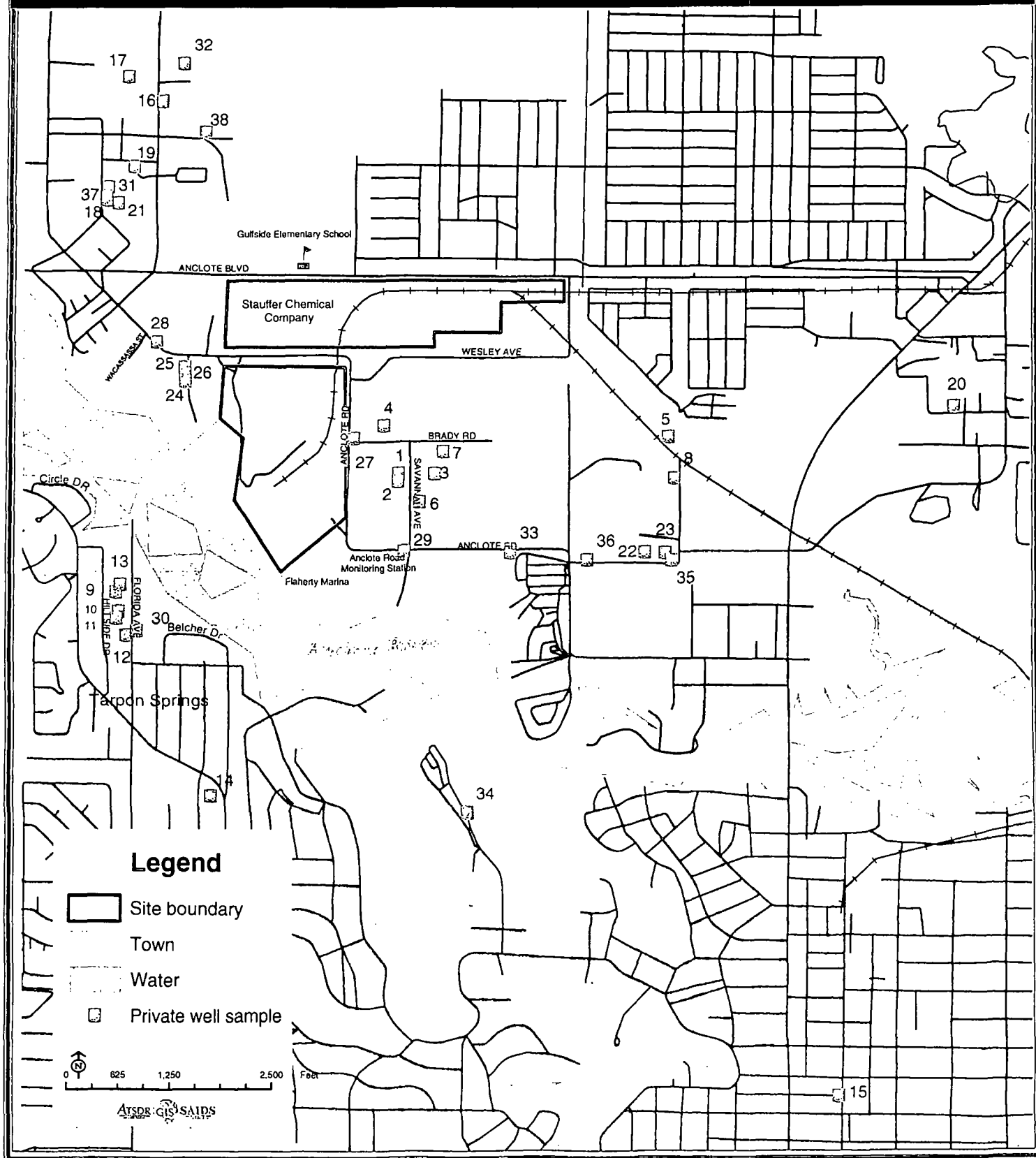
Tarpon Springs, Florida



Agency for Toxic Substances and Disease Registry

Figure 6. Private well sample locations

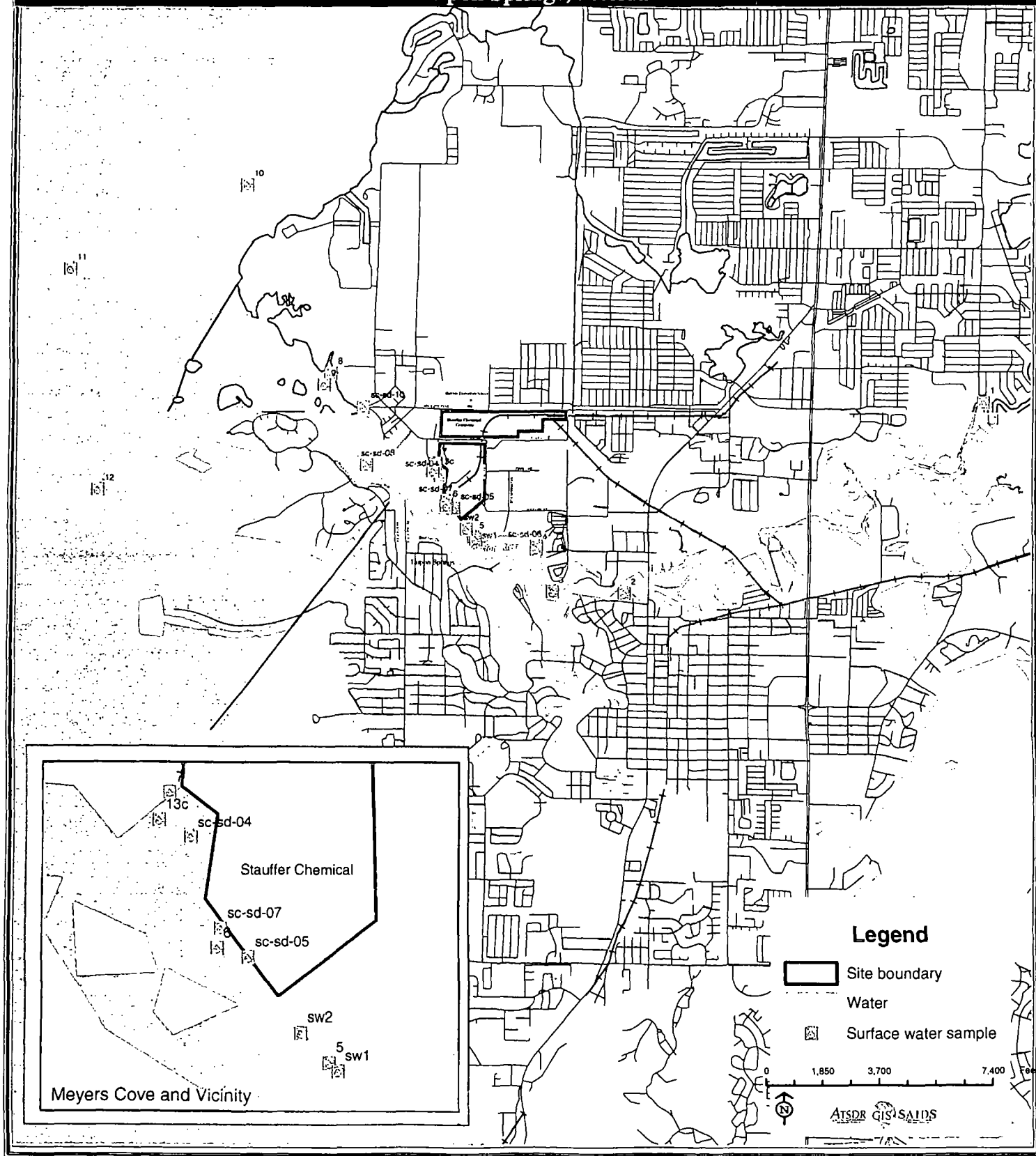
Tarpon Springs, Florida



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Figure 7. Surface water sampling locations

Tarpon Springs, Florida



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Figure 8. Sediment sampling locations

Tarpon Springs, Florida

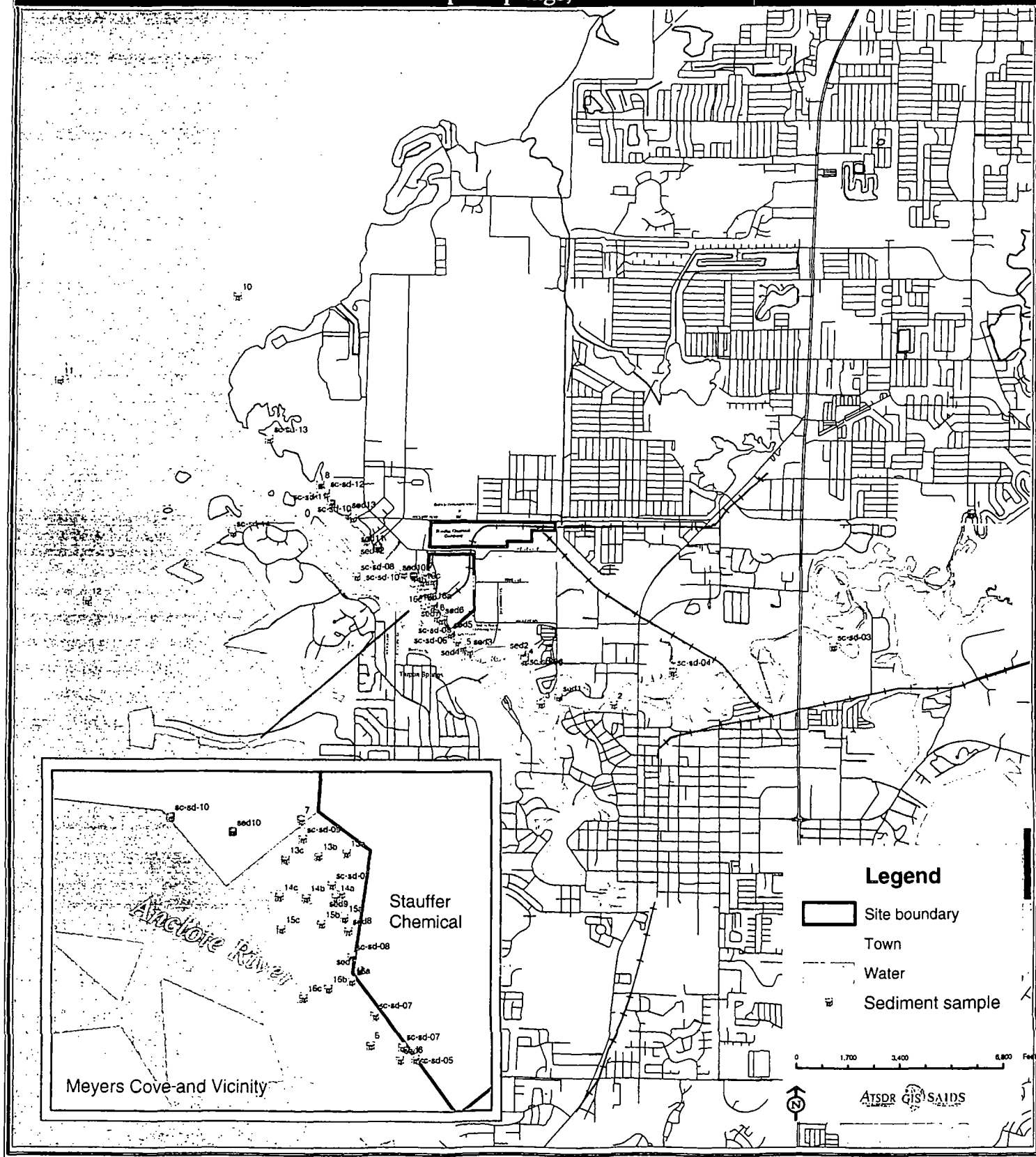
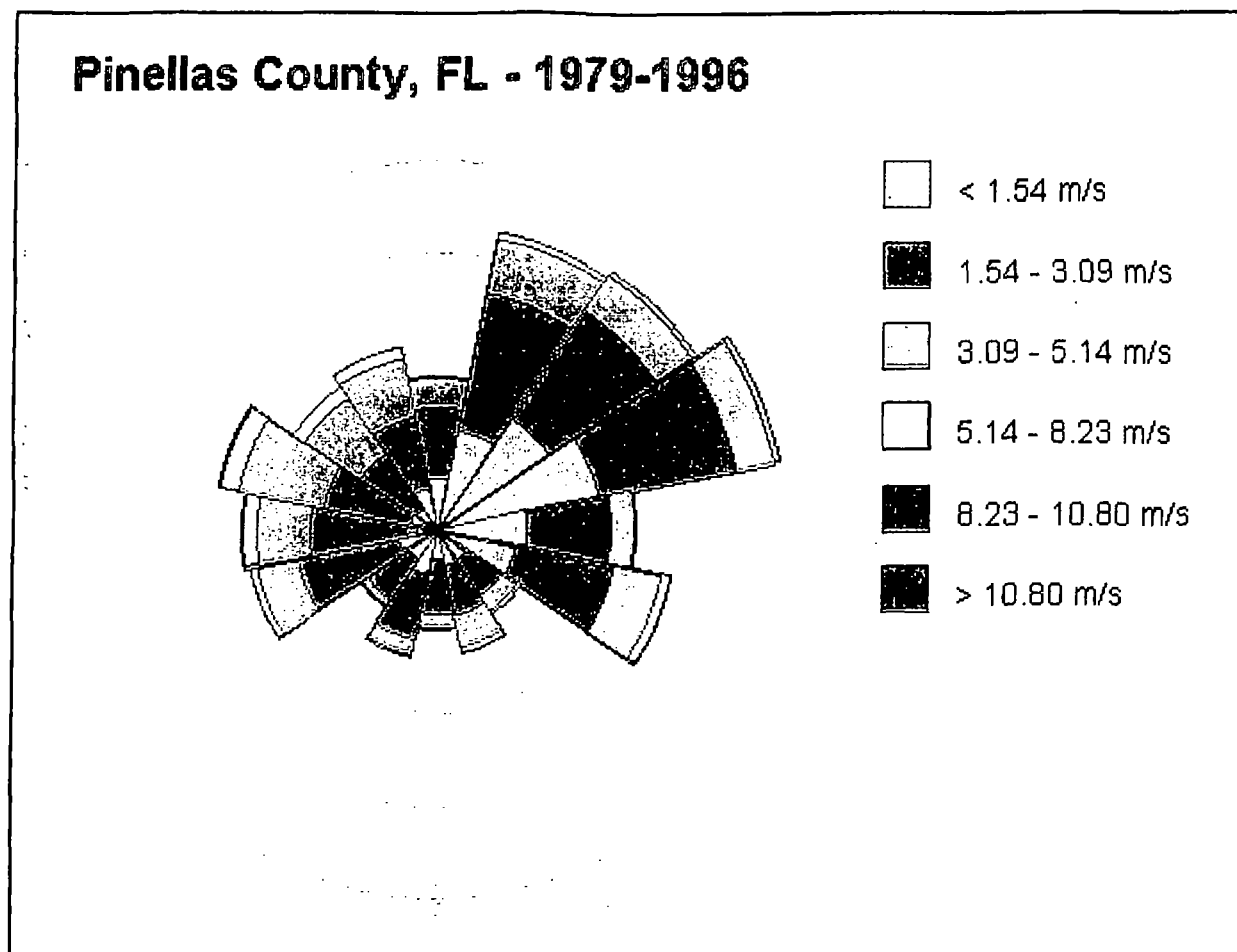
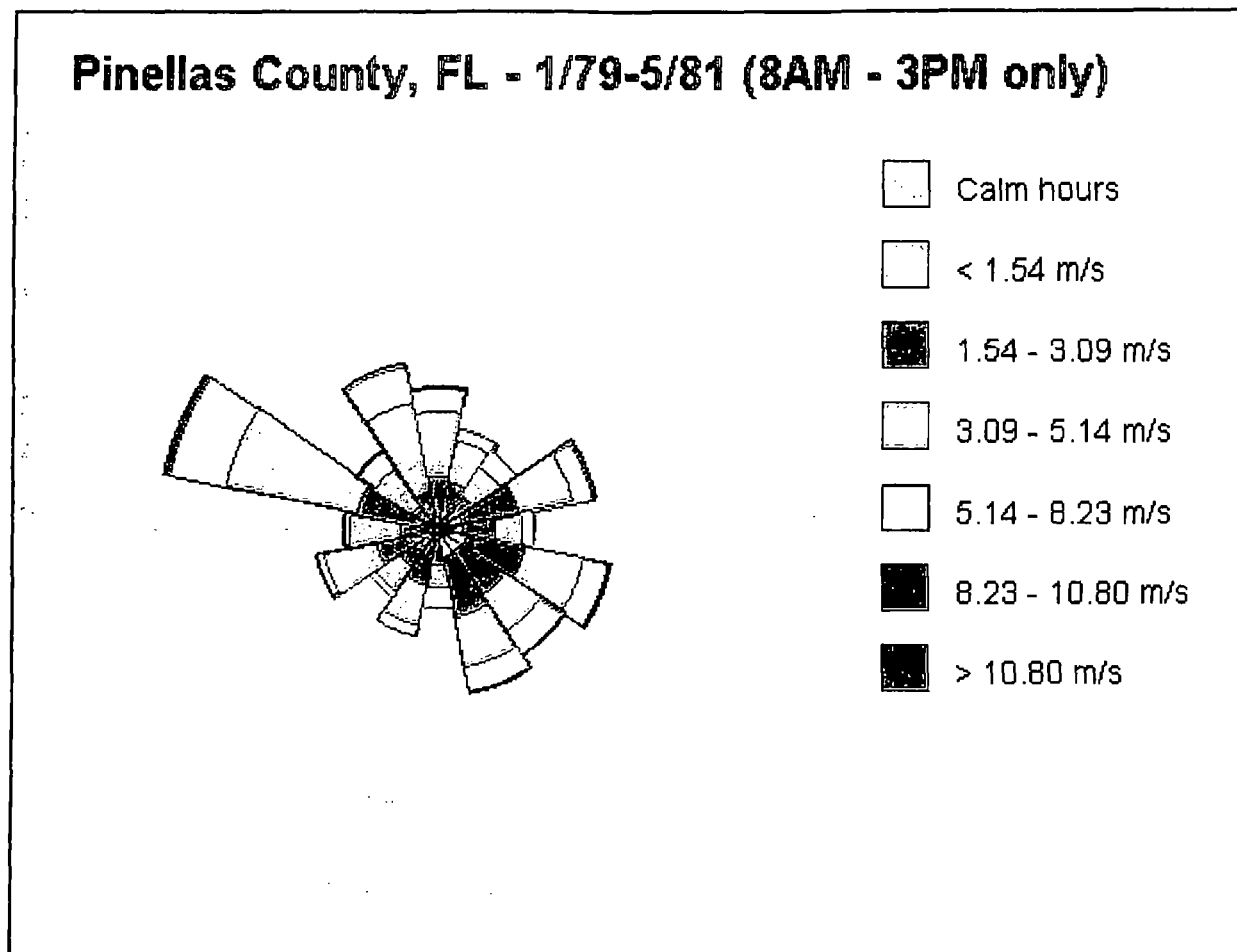


Figure 9
Wind Rose for PCDEM's Anclote Road Meteorological Station: 1979-1996



Notes: Data source: PCDEM 2002.
Bars in the figure indicate the direction *from which* wind was blowing.
m/s - meters per second

Figure 10
Wind Rose for PCDEM's Anclote Road Meteorological Station:
January 1979–May 1981, 8:00 AM–3:00 PM



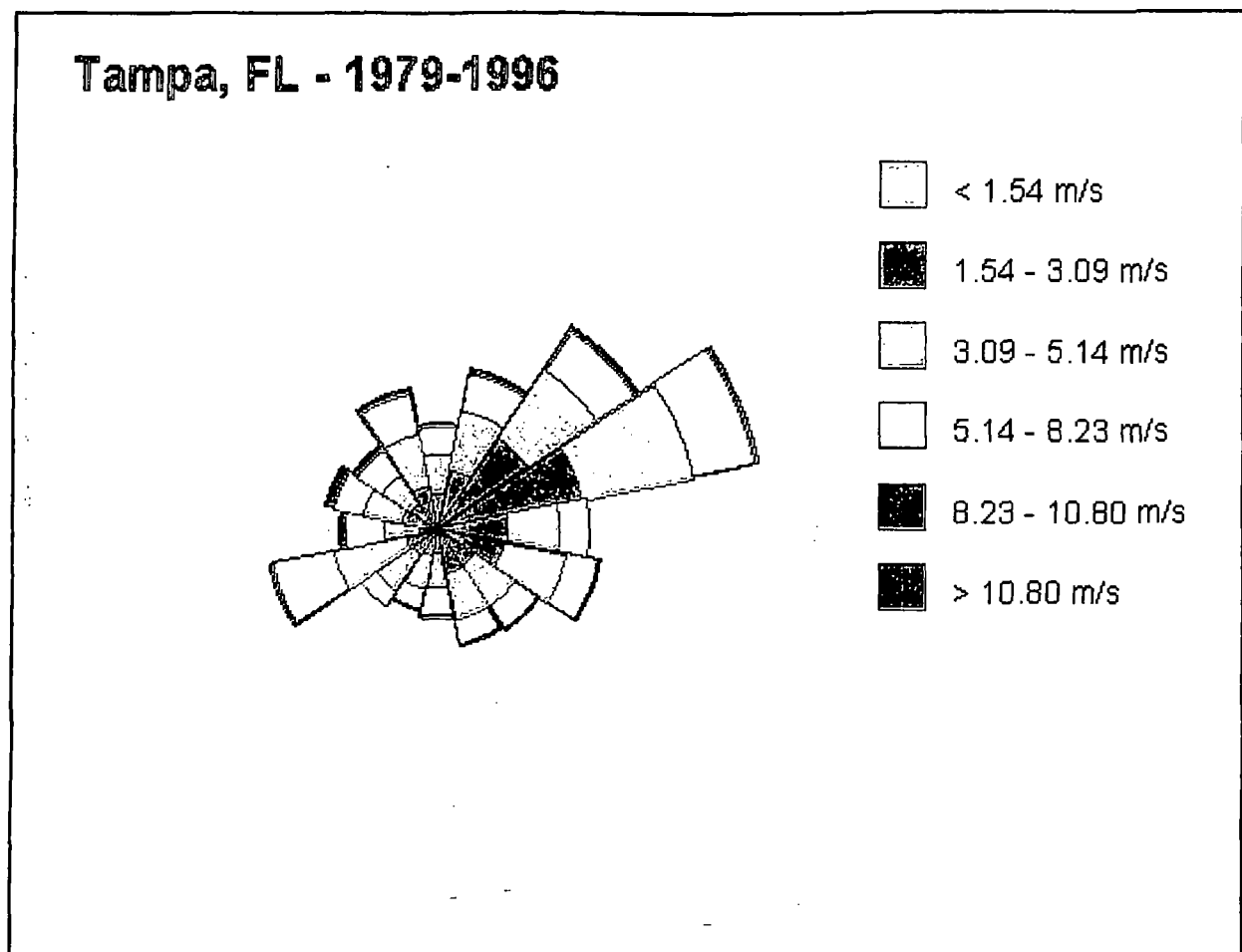
Notes: Data source: PCDEM 2002.

Bars in the figure indicate the direction *from which* wind was blowing.

Wind rose depicts prevailing wind patterns for the time frame when all three of the following conditions were met: (a) this meteorological station was reporting valid data, (b) Gulfside Elementary School was open, and (c) SCC production processes were still operating.

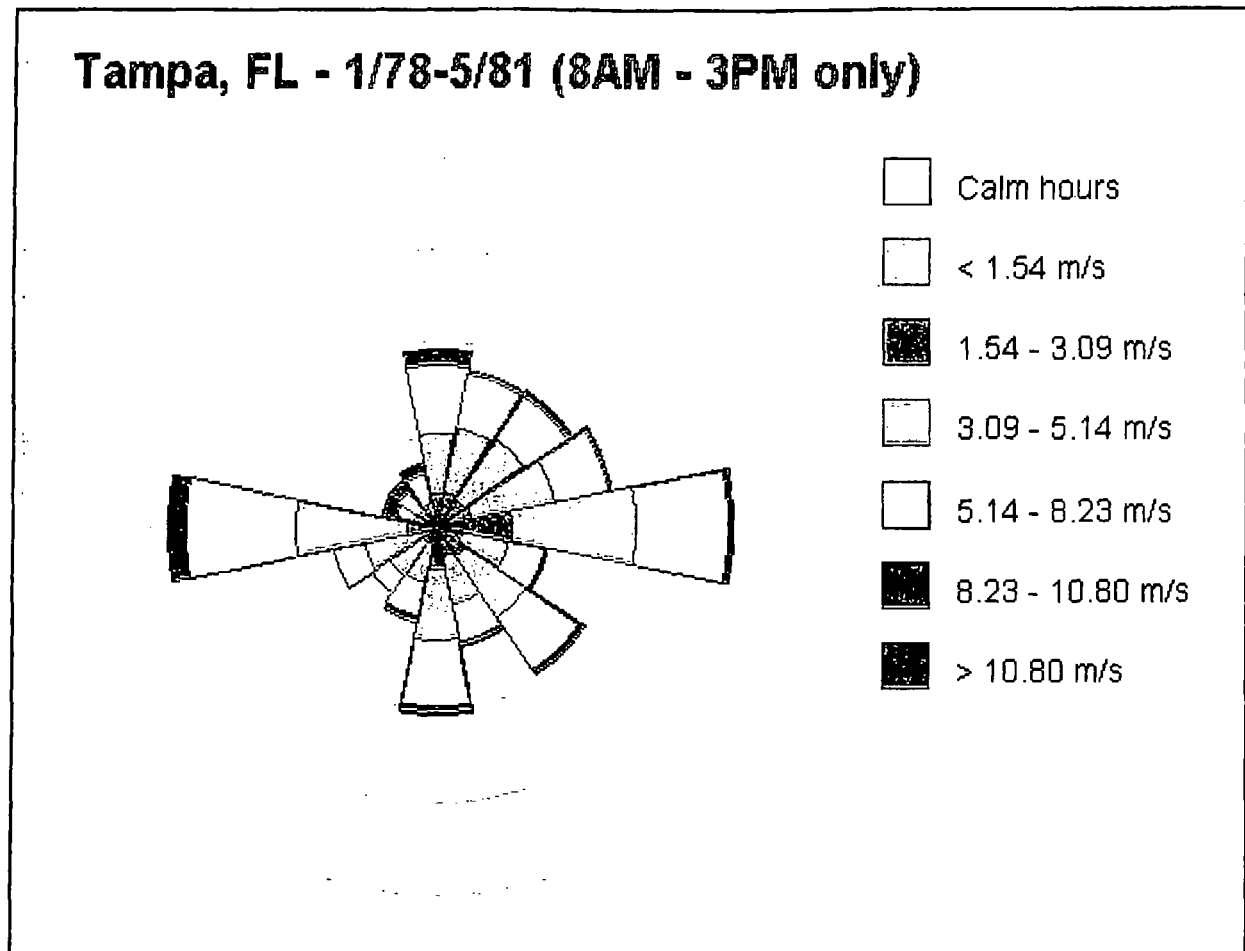
m/s - meters per second

Figure 11
Wind Rose for Tampa International Airport: 1979-1996



Notes: Data source: NCDC 2002.
Bars in the figure indicate the direction *from which* wind was blowing.
m/s - meters per second

Figure 12
Wind Rose for Tampa International Airport:
January 1978–May 1981, 8:00 AM–3:00 PM



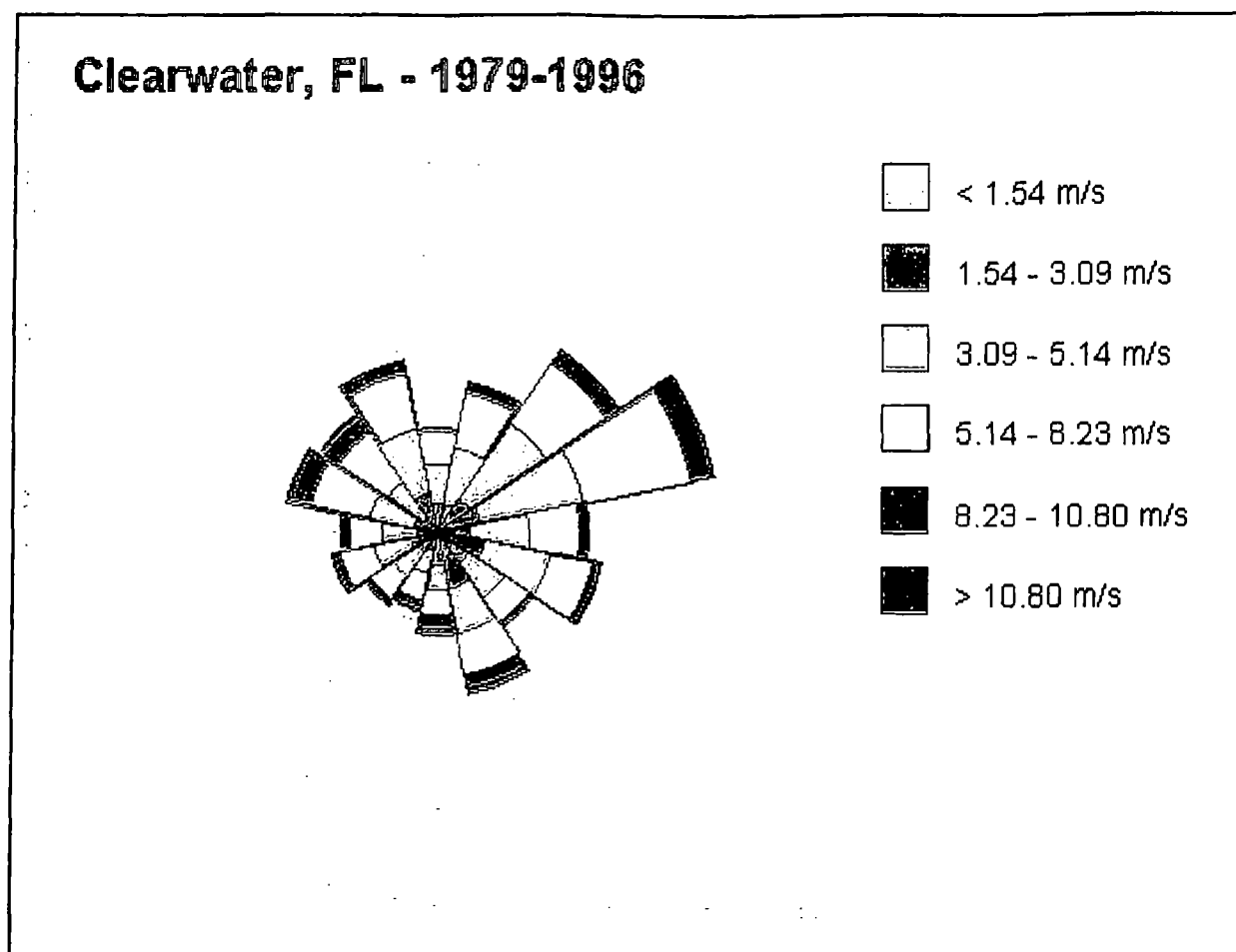
Notes: Data source: NCDC 2002.

Bars in the figure indicate the direction *from which* wind was blowing.

Wind rose depicts prevailing wind patterns for the time frame when all three of the following conditions were met: (a) this meteorological station was reporting valid data, (b) Gulfside Elementary School was open, and (c) SCC production processes were still operating.

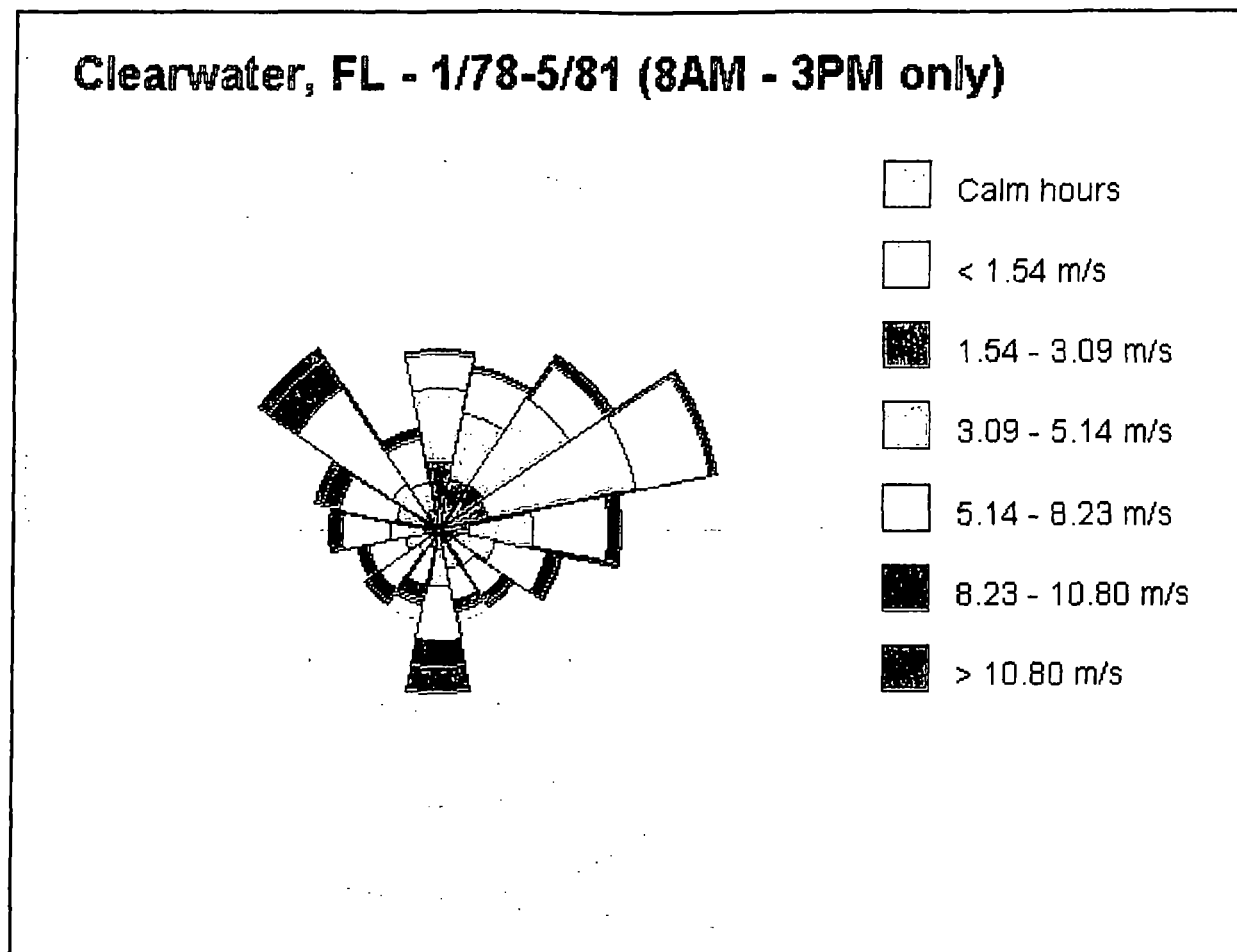
m/s - meters per second

Figure 13
Wind Rose for St. Petersburg–Clearwater International Airport: 1979–1996



Notes: Data source: NCDC 2002.
Bars in the figure indicate the direction *from which* wind was blowing.
m/s - meters per second

Figure 14
Wind Rose for St. Petersburg–Clearwater International Airport:
January 1978–May 1981, 8:00 AM–3:00 PM



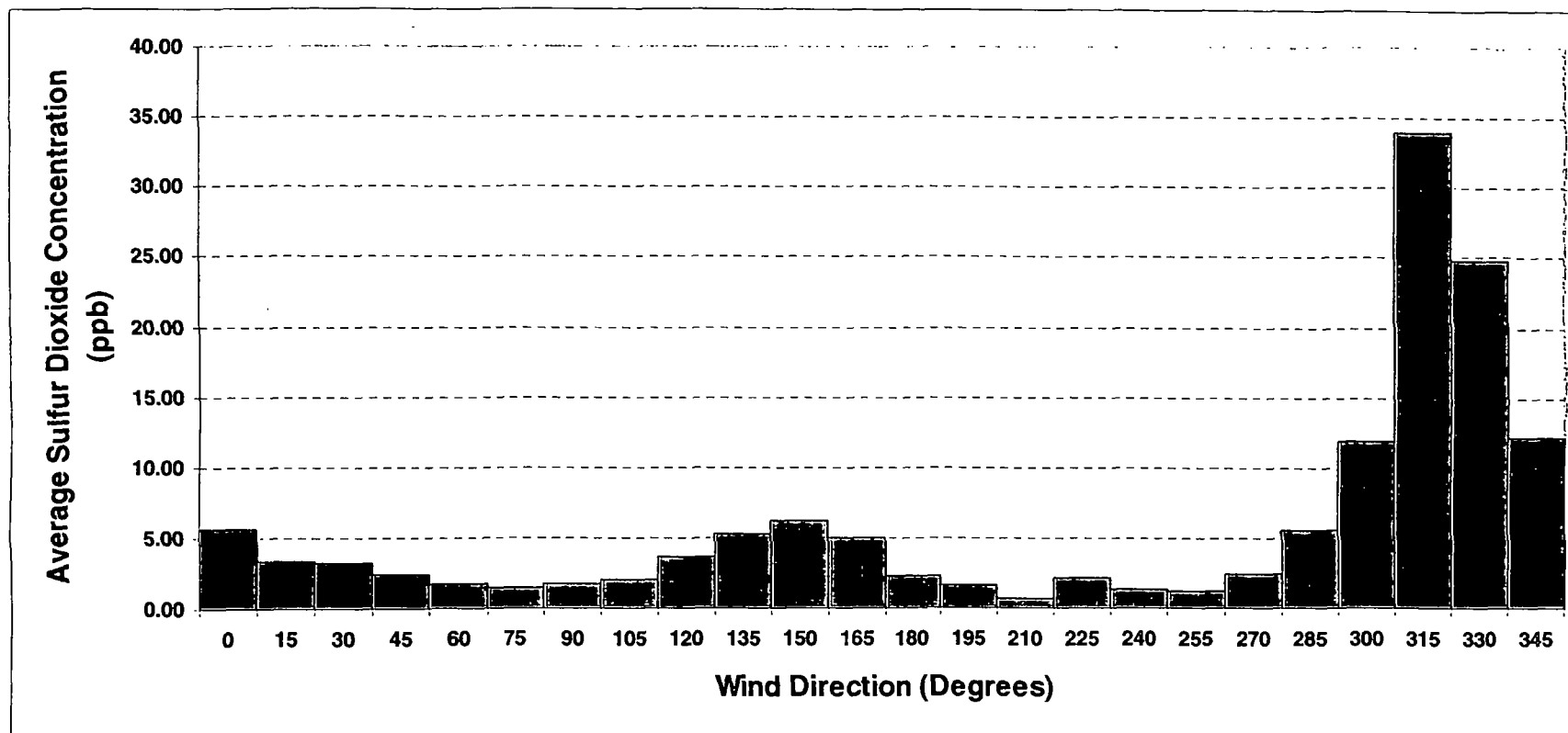
Notes: Data source: NCDC 2002.

Bars in the figure indicate the direction *from which* wind was blowing.

Wind rose depicts prevailing wind patterns for the time frame when all three of the following conditions were met: (a) this meteorological station was reporting valid data, (b) Gulfside Elementary School was open, and (c) SCC production processes were still operating.

m/s - meters per second

Figure 15
Average Sulfur Dioxide Concentrations at the Anclo Road Monitoring Stations, by Wind Direction:
1979-1981



Notes: Data sources: PCDEM 2002, EPA 2002.

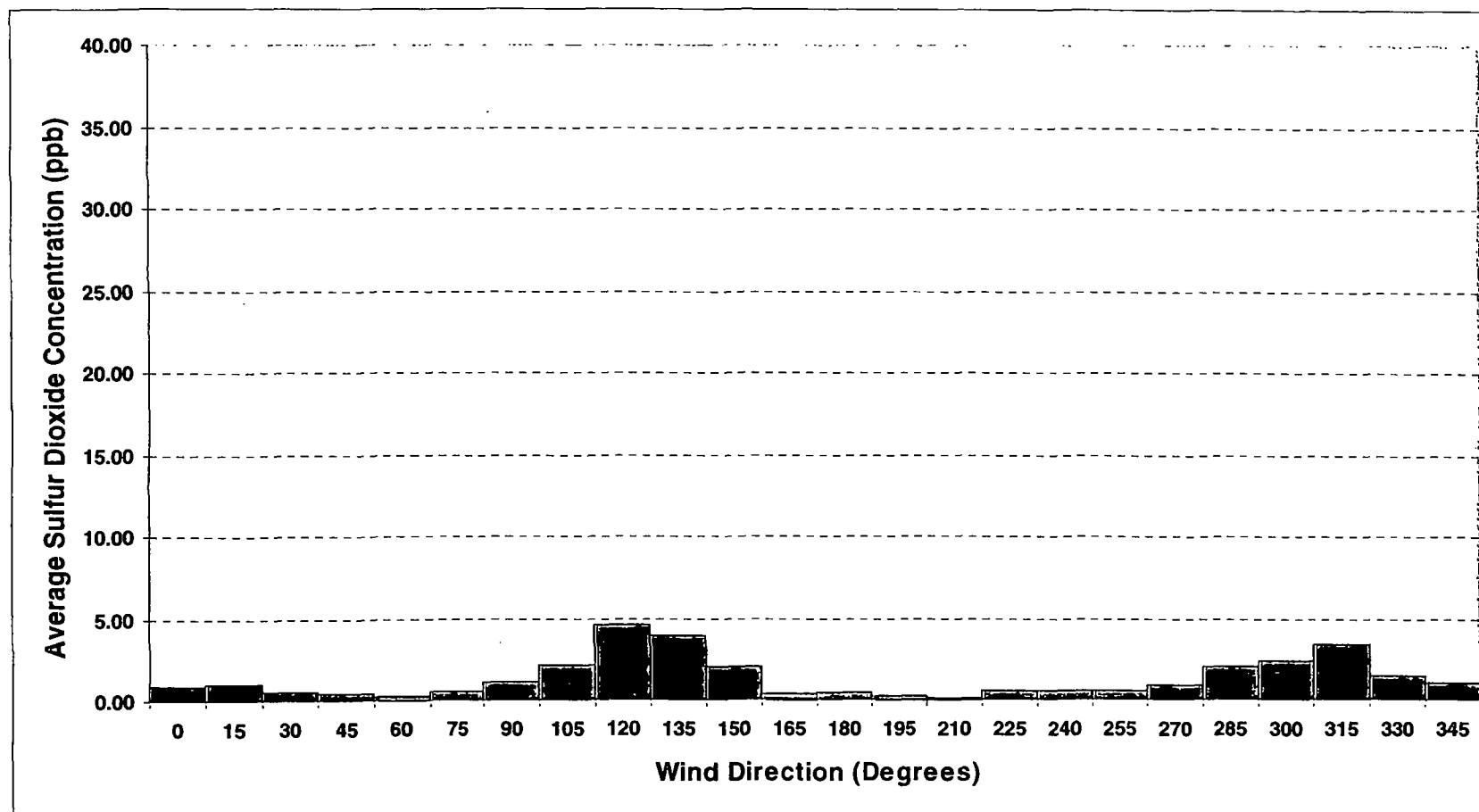
The time frame 1979 to 1981 was selected because it is the only period during which hourly wind direction and sulfur dioxide concentrations were simultaneously measured at the Anclo Road monitoring station while SCC operated. Valid, simultaneous measurements of these parameters were available for 21,848 hours between 1979 and 1981.

Between 1979 and 1981, PCDEM reported wind direction to the nearest 15° interval, with some exceptions. Out of the 21,848 hours of data available, 23 observations (or 0.1%) were reported to the nearest 5° interval. These observations were assigned to the nearest 15° interval for the analysis shown above.

Wind directions between 300° and 360° (or 0°) blew from the SCC facility to the monitoring station. A wind direction of 315° blew from the rotary kiln stack to the monitoring station.

ppb - parts per billion

Figure 16
Average Sulfur Dioxide Concentrations at the Ancote Road Monitoring Stations, by Wind Direction:
1982–1984



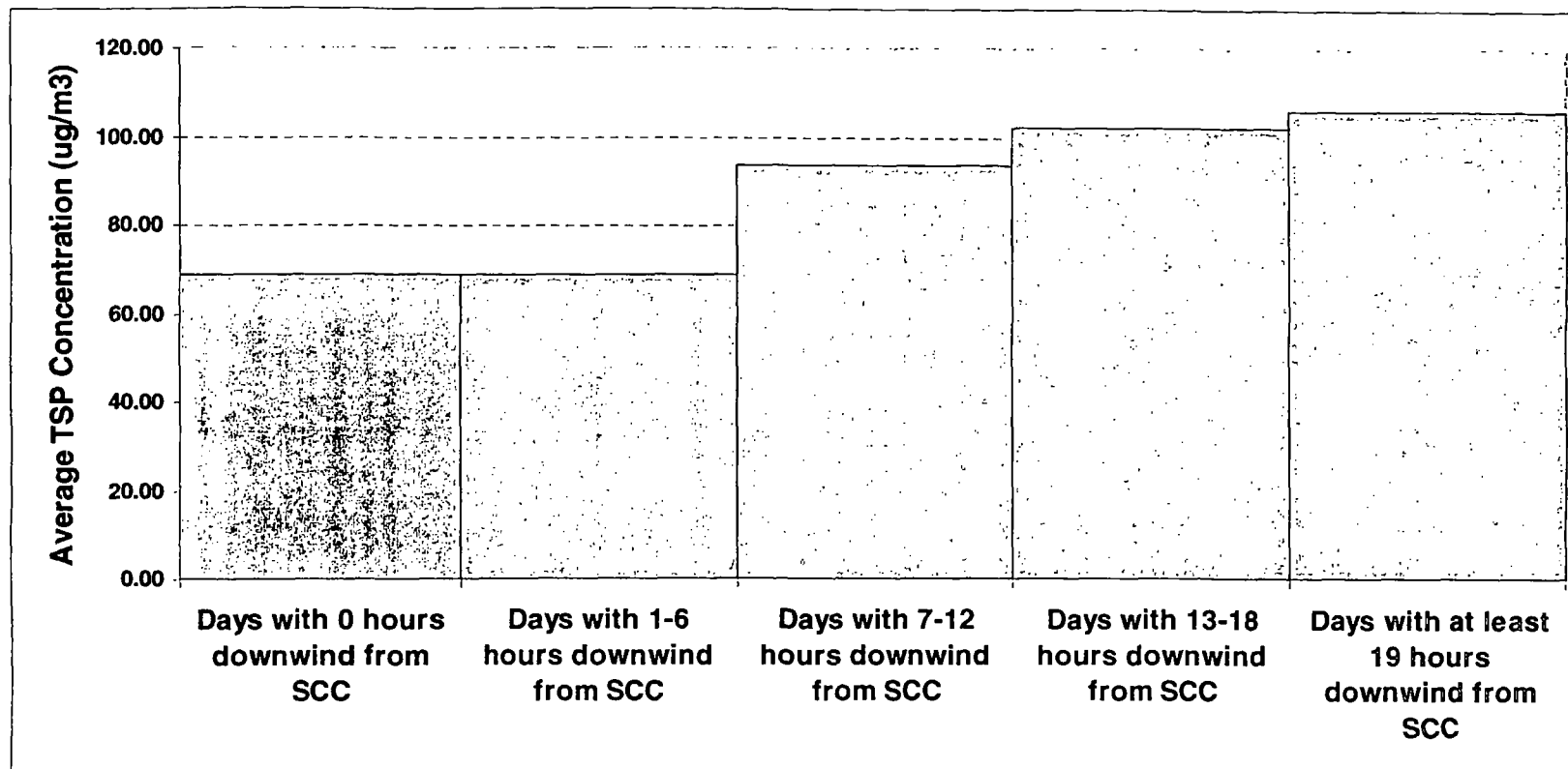
Notes: Data sources: PCDEM 2002, EPA 2002.

The time frame 1982 to 1984 was selected to evaluate air quality in the years immediately following SCC's closure. Valid, simultaneous measurements of these parameters were available for 23,484 hours between 1982 and 1984.

Between 1982 and 1984, PCDEM reported wind direction to the nearest 15° interval, with some exceptions. Out of the 23,484 hours of data available, 11 observations (or 0.05%) were reported to the nearest 5° interval. These observations were assigned to the nearest 15° interval for the analysis shown above.

ppb - parts per billion

Figure 17
Average TSP Concentrations at the Anclothe Road Monitoring Station, by Wind Direction: 1979–1981



Notes: Data sources: PCDEM 2002, EPA 2002.

An hour "downwind from SCC" was defined as any hour when the wind direction at the Anclothe Road station was between 300° and 360° (or 0°).

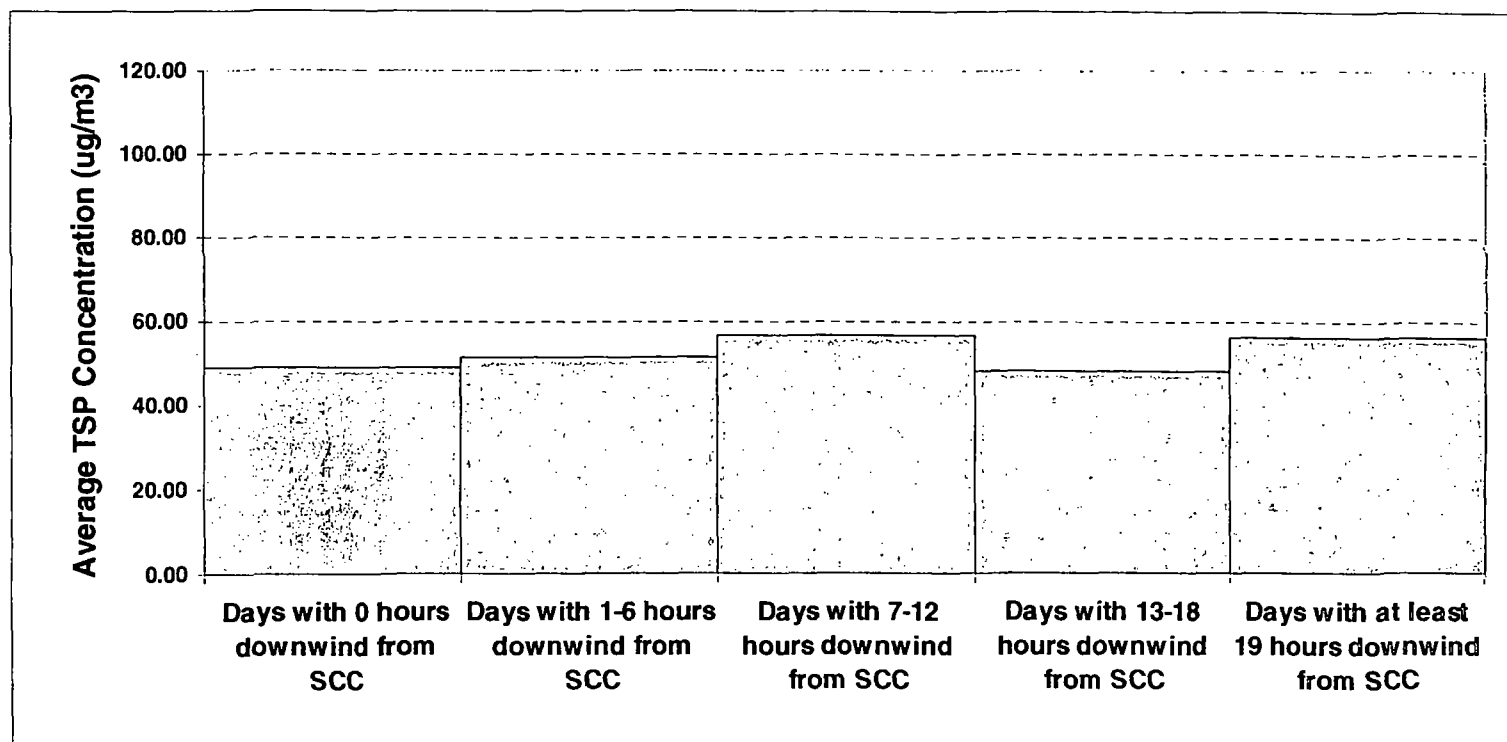
PCDEM collected 170 valid TSP samples between 1979 and 1981; 23 of these samples were not considered in this analysis because more than 4 hours of wind direction data on those days were invalid. The number of remaining samples were distributed among the five categories shown above as follows: 48 samples collected on days with 0 hours downwind from SCC, 55 samples with 1–6 hours downwind from SCC, 26 samples with 7–12 hours downwind from SCC, 11 samples with 13–18 hours downwind from SCC, and 7 samples with at least 19 hours downwind from SCC.

TSP - total suspended particulates

ug/m³ - micrograms per cubic meter

SCC - Stauffer Chemical Company

Figure 18
Average TSP Concentrations at the Anclole Road Monitoring Station, by Wind Direction: 1982–1984



Notes: Data sources: PCDEM 2002, EPA 2002.

An hour "downwind from SCC" was defined as any hour when the wind direction at the Anclole Road station was between 300° and 360° (or 0°).

PCDEM collected 168 valid TSP samples between 1982 and 1984; 14 of these samples were not considered in this analysis because more than 4 hours of wind direction data on those days were invalid. The number of remaining samples were distributed among the five categories shown above as follows: 39 samples collected on days with 0 hours downwind from SCC, 58 samples with 1–6 hours downwind from SCC, 32 samples with 7–12 hours downwind from SCC, 16 samples with 13–18 hours downwind from SCC, and 9 samples with at least 19 hours downwind from SCC.

TSP - total suspended particulates

ug/m³ - micrograms per cubic meter

SCC - Stauffer Chemical Company

Agency for Toxic Substances and Disease Registry
Figure 19. Air modeling receptor locations

Tarpon Springs, Florida

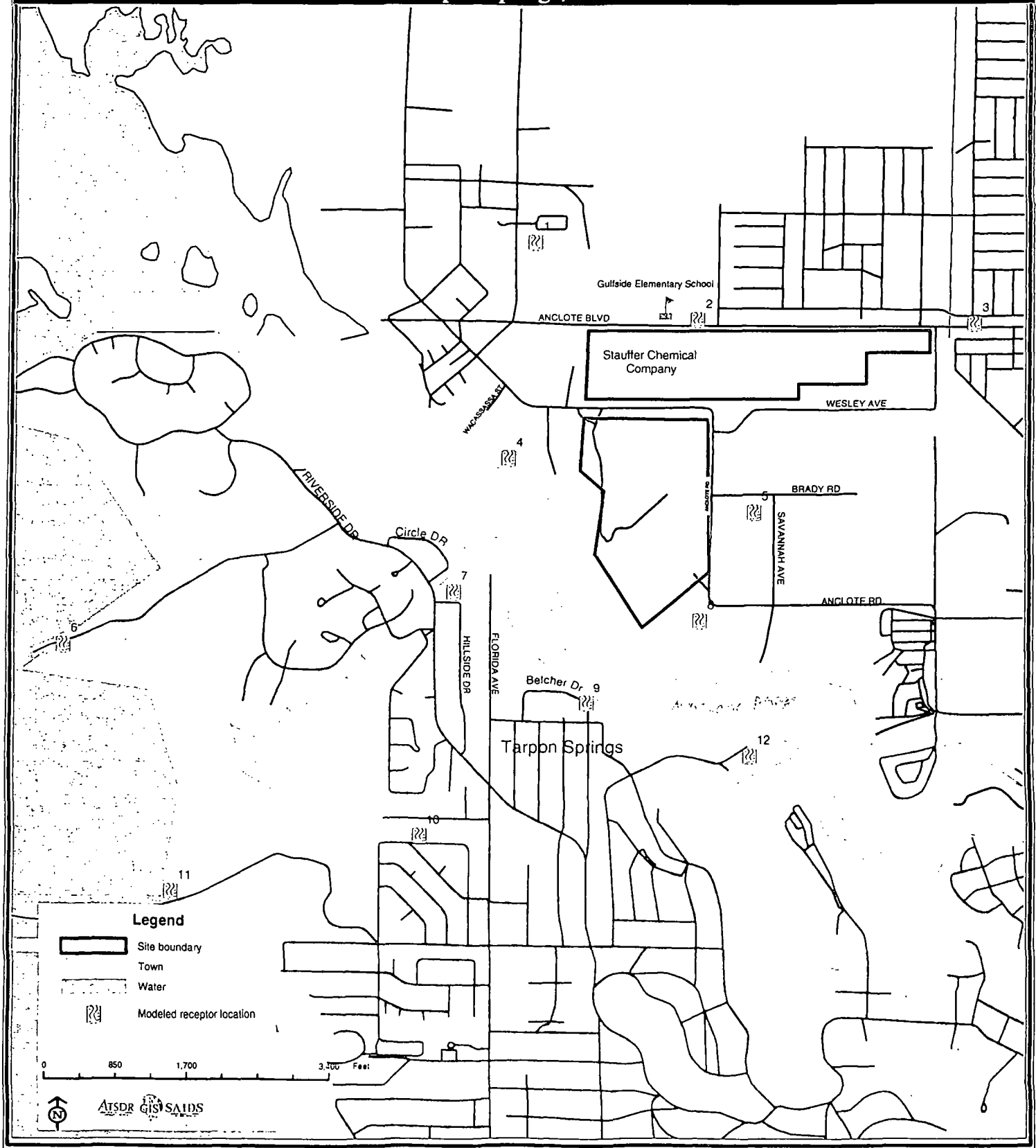


Figure 20. Hourly Sulfur Dioxide Levels From July 1977 to August 1981

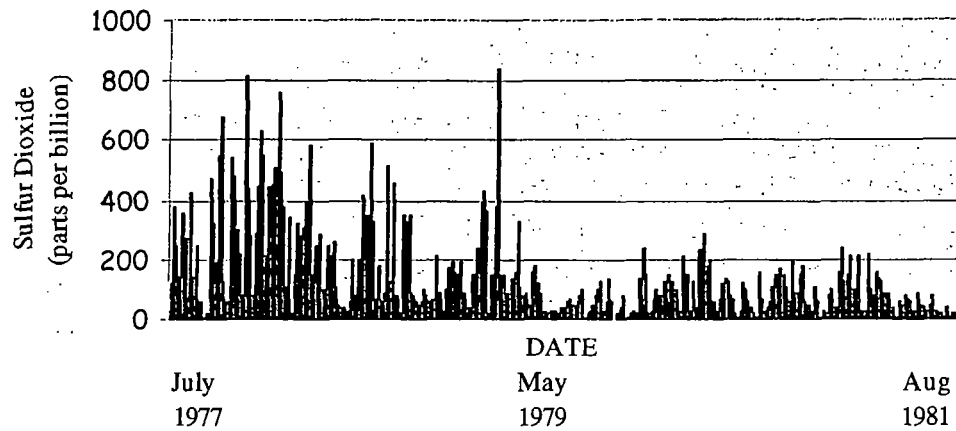
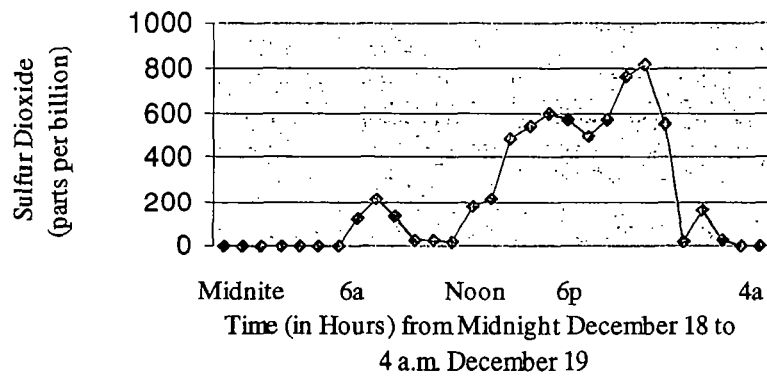
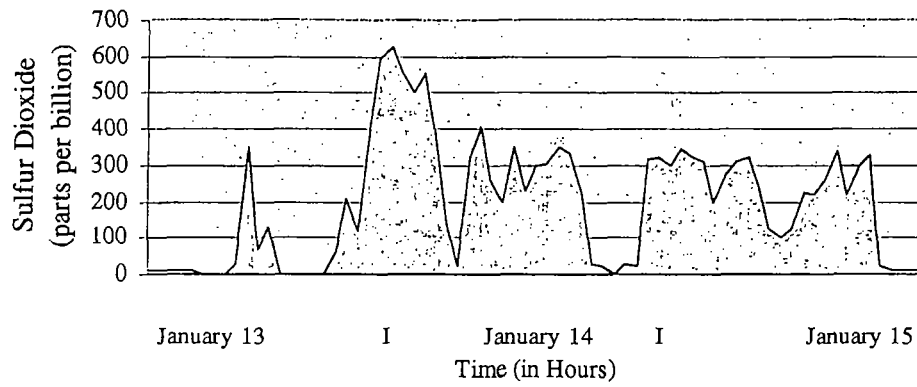


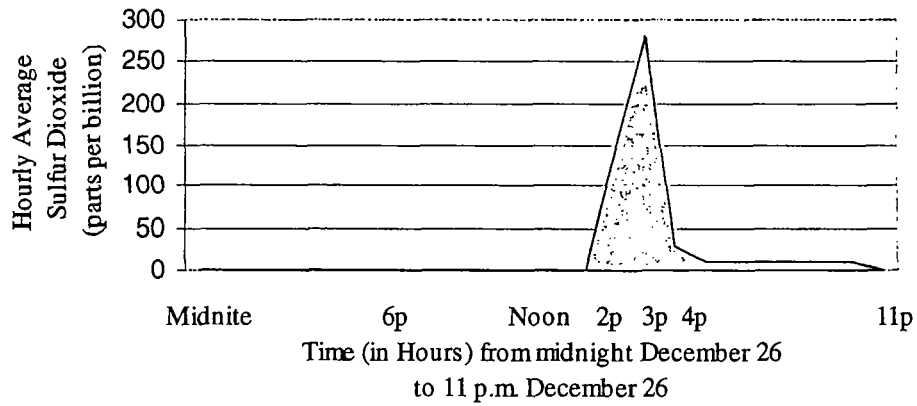
Figure 21. Hourly Sulfur Dioxide Levels on December 18, 1977



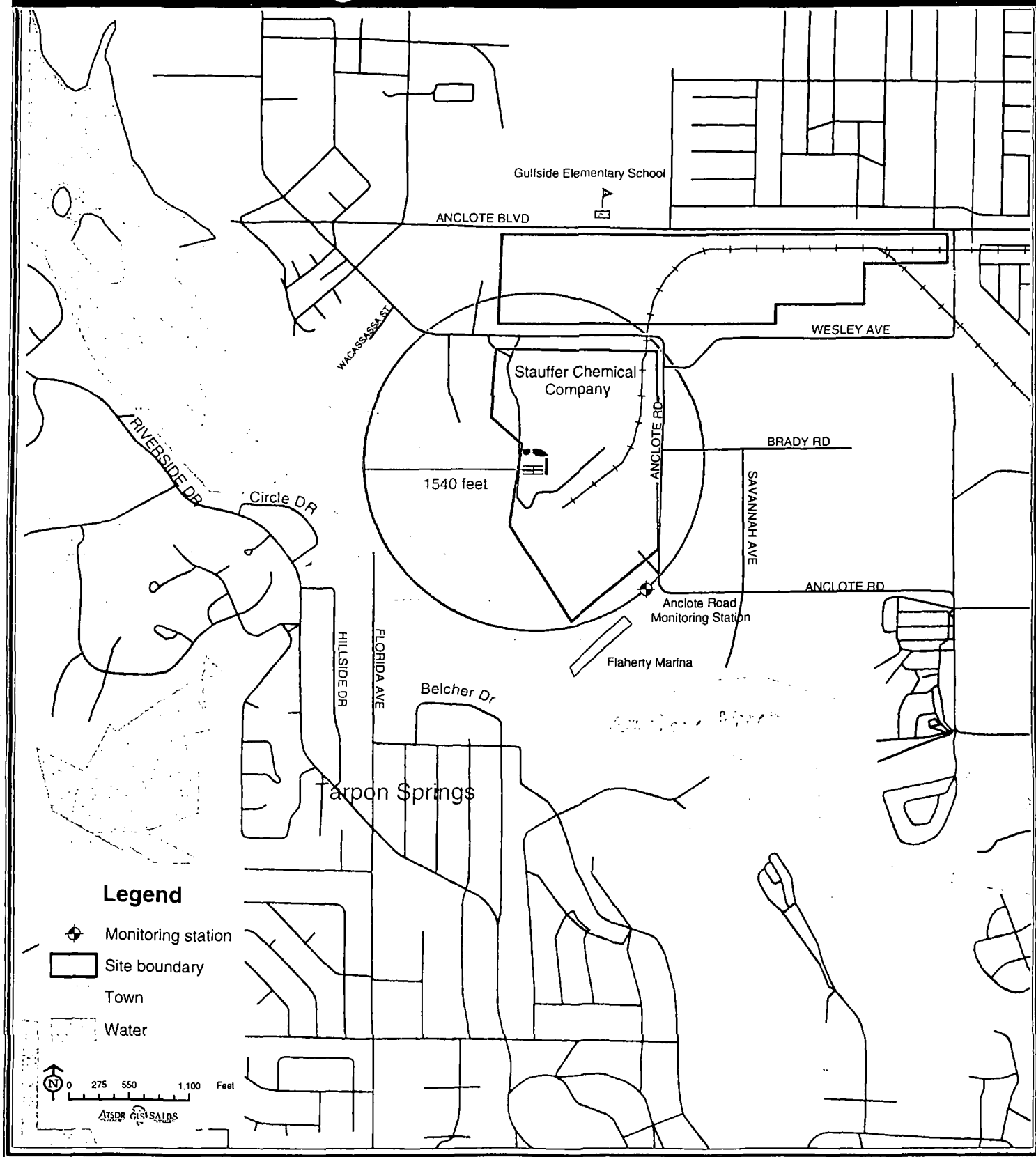
**Figure 22. Hourly Sulfur Dioxide Levels Over 3 Days
In January 1978**



**Figure 23. Hourly Sulfur Dioxide Levels on
December 26, 1977**

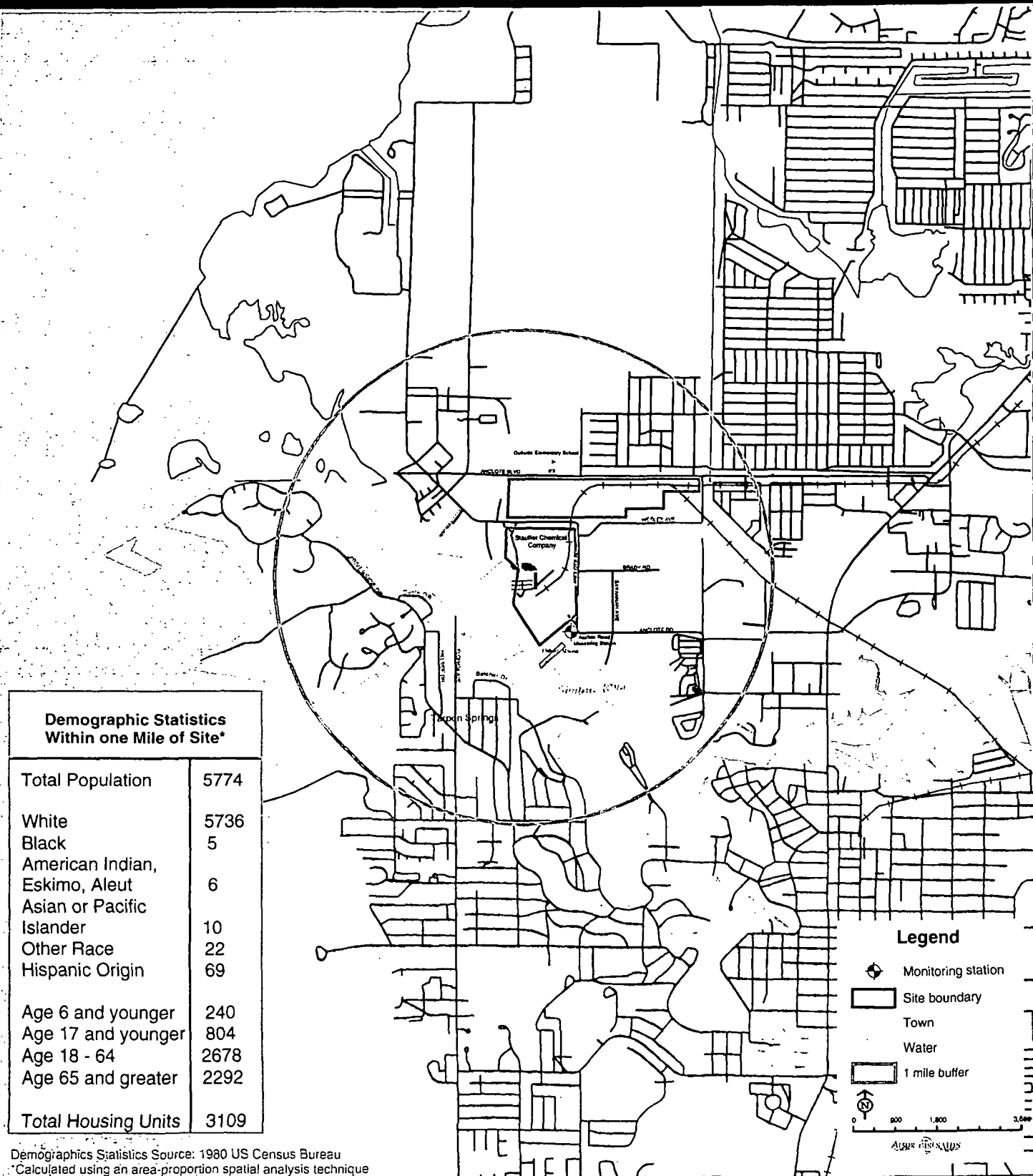


**Figure 24. Anclore Road monitoring station
showing 1,540 feet radius from kiln**



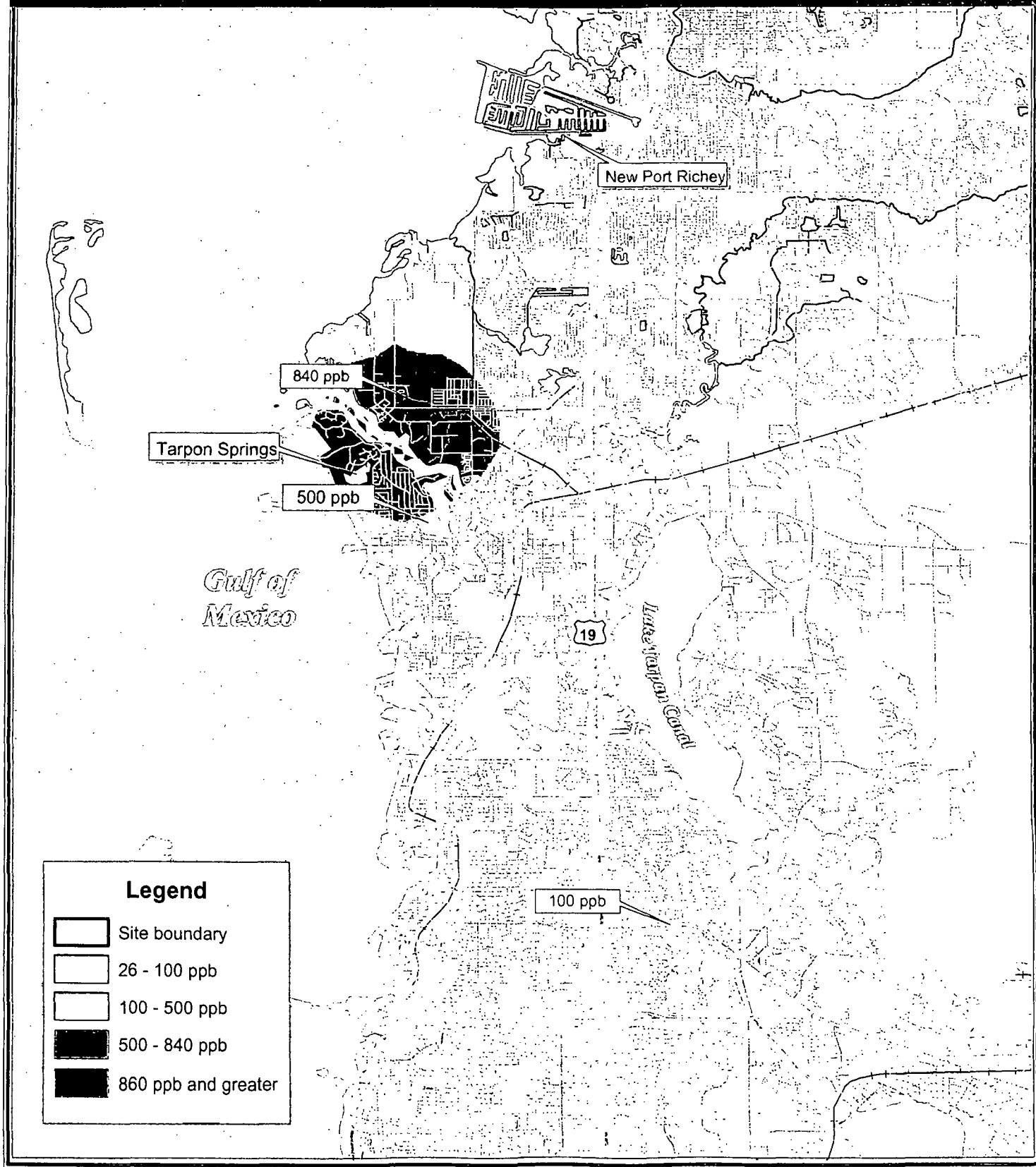
Agency for Toxic Substances and Disease Registry

Figure 25. One mile radius 1980 demographic information



Stauffer Chemical Site

Figure 26. Predicted maximum hourly sulfur dioxide levels
1977 to 1981



Stauffer Chemical Site

Figure 27. Predicted Average annual sulfur dioxide levels
1977 to 1981

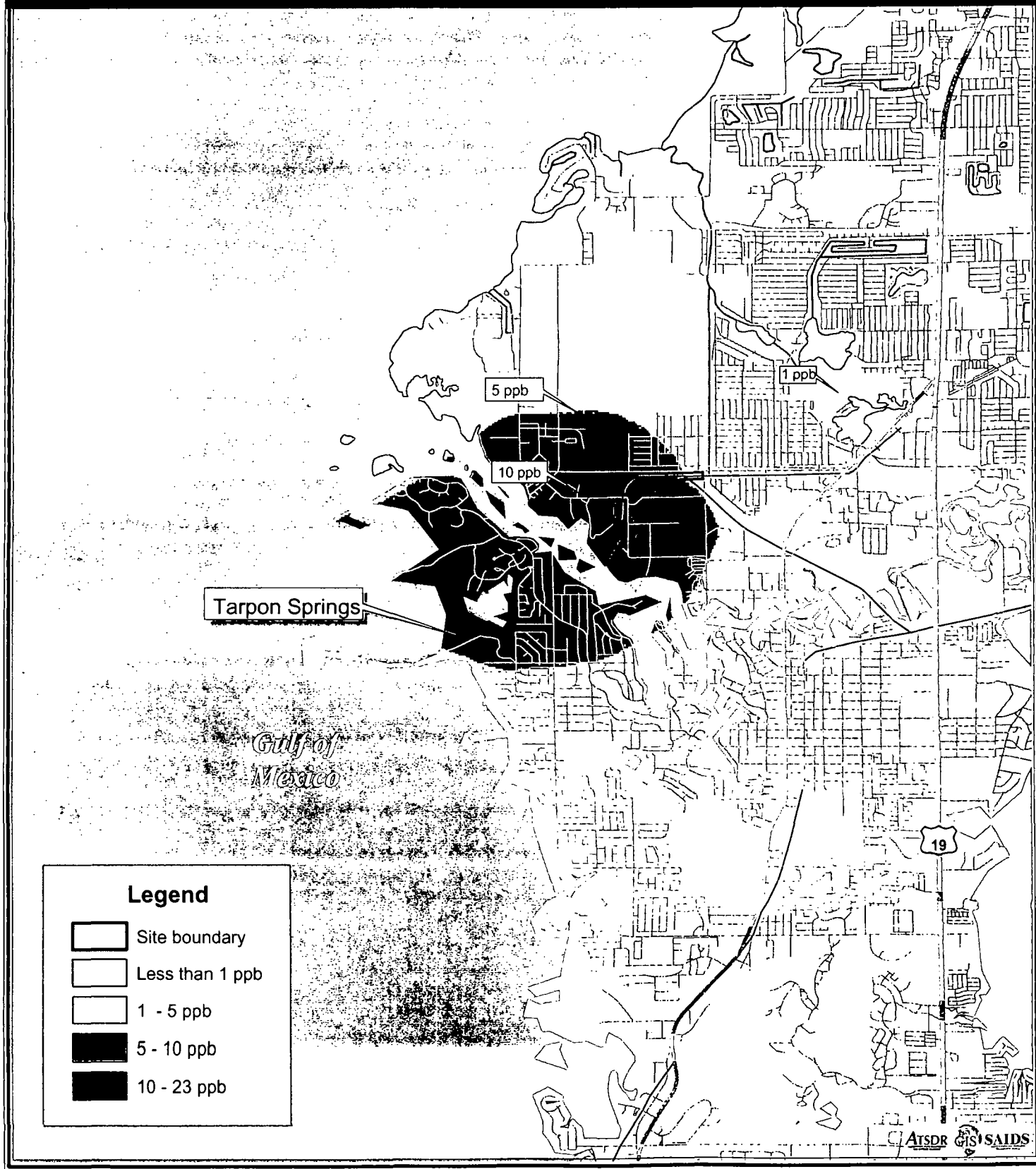


Table 1. Stauffer Chemical Company Site, Former Ponds/Dredged Material Piles Designations

Pond/Pile	Location	Sample Point	Date	Description
39	Northeast property	SB-02SZ	January 1988	Subsurface: saturated zone
		39-1C	December 1989	Composite depths
		SC-L7-01	April 1989	Surface soil
		SC-L7-02	April 1989	Surface soil
		SC-L7-03	April 1989	Subsurface: 3 feet
42	Western portion of the main production area	SB-12SZ	January 1988	Subsurface: saturated zone
		SC-L5-01	April 1989	Surface soil
		SC-L5-02	April 1989	Surface soil
		SC-L5-03	April 1989	Subsurface: 3 feet
		42-1C	December 1989	Composite depths
		SS68	September 1990	Surface soil
44A	Main production area; near power house and slag pits	44A-1C	December 1989	Composite depths
44B	Main production area; near power house and slag pits	44B-1C	December 1989	Composite depths
45	Main production area; near power house and slag pits	45-1C	December 1989	Composite depths
46A	Southern portion of the main production area	46A-2-5C	December 1989	Composite depths
46B	Southern portion of the main production area	46B-3-3C	December 1989	Composite depths
47	Southern portion of the main production area	47-3-1C	December 1989	Composite depths

Table 1. Stauffer Chemical Company Site, Former Ponds/Dredged Material Piles Designations (continued)

Pond/Pile	Location	Sample Point	Date	Description
48	Southern portion of the main production area	48-6-9C	December 1989	Composite depths
		PM93-2	March 1993	Surface soil
49A	Southern portion of the main production area	SC-SS-04	January 1988	Surface soil
		SC-L1-01	April 1989	Surface soil
		SC-L1-02	April 1989	Surface soil
		SC-L1-03	April 1989	Subsurface: 3 feet
		SC-L3-01	April 1989	Surface soil
		SC-L3-02	April 1989	Surface soil
		SC-L3-03	April 1989	Subsurface: 3 feet
		49A-6-23C	December 1989	Composite depths
		PM93-1 (two samples)	March 1993	Surface soil
49B	Southern portion of the main production area	SC-L2-01	April 1989	Surface soil
		SC-L2-02	April 1989	Surface soil
		SC-L2-03	April 1989	Subsurface: 3 feet
		49B-9-21C	December 1989	Composite depths
49C	Southern portion of the main production area	SC-SS-03	January 1988	Surface soil
		49C-9-13C	December 1989	Composite depths

Table 1. Stauffer Chemical Company Site, Former Ponds/Dredged Material Piles Designations (continued)

Pond/Pile	Location	Sample Point	Date	Description
49D	Southern portion of the main production area	49D-7-11C (two samples)	December 1989	Composite depths
		SS69	September 1990	Surface soil
49E	Southern portion of the main production area	SC-L4-01	April 1989	Surface soil
		SC-L4-02	April 1989	Surface soil
		SC-L4-03	April 1989	Subsurface: 3 feet
		49E-8-10C	December 1989	Composite depths
50	Southern portion of the main production area	This area was covered over by growth at the time of sampling (December 1989). Elemental phosphorus was found in borings during a preliminary investigation. No other samples were collected from this area.		
51	Southern portion of the main production area	SC-L6-01	April 1989	Surface soil
		SC-L6-02	April 1989	Surface soil
		SC-L6-03	April 1989	Subsurface: 3 feet
		51-4-5C	December 1989	Composite depths
		PM93-3	March 1993	Surface soil
52	Northeast portion of the slag storage area	52-1C	December 1989	Composite depths
Pile 1	Dredged material from pond 39; northeast property	SC-SS-02	January 1988	Surface composite

Table 1. Stauffer Chemical Company Site, Former Ponds/Dredged Material Piles Designations (continued)

Pond/Pile	Location	Sample Point	Date	Description
Pile 2	Dredged pond materials from ponds 49A, 49B, 49C, and 51 in the southern portion of the main production area	SB-08A	January 1988	Subsurface: 4 feet
		SB-08B	January 1988	Subsurface: 10 feet
		SB-08C	January 1988	Subsurface: 15 feet
		SC-P2-01	April 1989	Surface soil
		SC-P2-02	April 1989	Surface soil
		SC-P2-03	April 1989	Subsurface: 8 feet
Pile 3	Dredged material from pond 42; western portion of the main production area	SC-P3-01	April 1989	Surface soil
		SC-P3-02	April 1989	Surface soil
		SC-P3-03	April 1989	Subsurface: 5 feet
Pile 4	Area of a former pile of dredged pond material in southeast property; nearest to pond 49C	SS93-17	March 1993	Surface soil

Table 2. On-Site Soil Sampling Summary Data, Pond Soils

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Volatile Organic Compounds (VOCs)								
2-Butanone	0.007 J	0.007 J	SS69 surface	Sept-90	1/7	22,000	RBC-N	0
Acetone	0.009 J,B	0.31	PM93-2 surface	Mar-93	4/7	20,000	child-RMEG	0
Methylene chloride	0.005 J	0.027	PM93-2 surface	Mar-93	5/7	90	CREG	0
Toluene	0.005	0.005	SS68 surface	Sept-90	1/8	1,000	child-I-EMEG	0
Trichloroethylene	0.003 J	0.003 J	SS69 surface	Sept-90	1/7	2	CREG	0
Semivolatile Organic Compounds (SVOCs)								
Anthracene	0.66 J	0.66 J	PM93-2 surface	Mar-93	1/7	20,000	child-RMEG	0
Benzo[a]anthracene	0.073 J	2.8 J	PM93-2 surface	Mar-93	2/8	0.87	RBC-C	1
Benzo[a]pyrene	0.11 J	0.15 J	SC-SS-03 surface composite and SS69 surface	Jan-88 and Sept-90	3/8	0.1	CREG	3
Benzo[b]fluoranthene	0.15 J	5.2	PM93-2 surface	Mar-93	5/8	0.87	RBC-C	1

Table 2. On-Site Soil Sampling Summary Data, Pond Soils (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Benzo[g,h,i]perylene	0.09 J	1.5 J	PM93-2 surface	Mar-93	4/7	20,000	child-RMEG, anthracene	0
Benzo[k]fluoranthene	0.052 J	1.1 J	PM93-2 surface	Mar-93	4/8	8.7	RBC-C	0
bis(2-Ethylhexyl) phthalate	0.3 J,B	2.2 J	PM93-2 surface	Mar-93	3/7	50	CREG	0
Chrysene	0.061 J	4.8	PM93-2 surface	Mar-93	4/8	87	RBC-C	0
di-n-Butyl phthalate	0.078 J,B	0.67 J,B	PM93-2 surface	Mar-93	5/7	5,000	child-RMEG	0
Fluoranthene	0.036 J	3.9	PM93-2 surface	Mar-93	4/8	2,000	child-RMEG	0
Indeno[1,2,3-cd] pyrene	0.11 J	1.8 J	PM93-2 surface	Mar-93	4/7	0.87	RBC-C	1
Phenanthrene	0.036 J	2 J	PM93-2 surface	Mar-93	3/7	2,000	child-RMEG, fluoranthene	0
Pyrene	0.1 J	3.3	PM93-2 surface	Mar-93	2/7	2,000	child-RMEG	0
Pesticides/Polychlorinated Biphenyls								
Arochlor 1248	3.1	3.1	SS69 surface	Sept-90	1/7	1	child-EMEG, arochlor 1254	1

Table 2. On-Site Soil Sampling Summary Data, Pond Soils (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Inorganics-Metals								
Aluminum (Al)	180	7,600	SC-SS-03 surface composite	Jan-88	42/42	100,000	child-I-EMEG	0
Antimony (Sb)	20.8	52	PM93-3 surface	Mar-93	10/15	20	child-RMEG	10
Arsenic (As)	4.2	340 J,N	SB12-SZ saturated zone	Jan-88	48/59	0.5	CREG	48
Barium (Ba)	2	140	SB12-SZ saturated zone	Jan-88	40/42	4,000	child-RMEG	0
Beryllium (Be)	0.71 X	2	PM93-1 surface	Mar-93	9/15	50	child-C-EMEG	0
Cadmium (Cd)	0.99	66 J	SB-02SZ saturated zone	Jan-88	54/59	10	child-C-EMEG	47
Calcium (Ca)	1,430	440,000 J	SC-SS-03 surface composite	Jan-88	42/42	NA	NA	NA
Chromium (Cr)	1.7	226	PM93-2 surface	Mar-93	58/59	200	child-RMEG Cr ⁶⁺	1
Cobalt (Co)	1.3 X	4.7	SS68 surface	Sept-90	5/15	500	child-I-EMEG	0
Copper (Cu)	1.8	1,040	PM93-2 surface	Mar-93	26/42	3,100	RBC-N	0

Table 2. On-Site Soil Sampling Summary Data, Pond Soils (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Iron (Fe)	24	12,000	SC-SS-02 surface composite	Jan-88	42/42	23,000	RBC-N	0
Lead (Pb)	1.6	900	PM93-2 surface	Mar-93	59/59	400	EPA AL	2
Magnesium (Mg)	39	14,000	SB-08C 15 feet/ dredge	Jan-88	40/42	NA	NA	NA
Manganese (Mn)	2.4	160	SB-08B 10 feet/ dredge	Jan-88	40/42	3,000	child-RMEG	0
Mercury (Hg)	0.095	2.2	PM93-2 surface	Mar-93	35/42	20	child-RMEG, HgCl ₂	0
Nickel (Ni)	2.7	43	SC-SS-02 surface composite	Jan-88	27/42	1,000	child-RMEG	0
Potassium (K)	174	4,820	PM93-3 surface	Mar-93	32/42	NA	NA	NA
Selenium (Se)	6.6	39 J, N	SC-SS-03 surface composite	Jan-88	30/42	300	child-C-EMEG	0
Silver (Ag)	2.8	19.3	PM93-2 surface	Mar-93	31/42	300	child-RMEG	0
Sodium (Na)	25.7	14,100	PM93-3 surface	Mar-93	30/42	NA	NA	NA

Table 2. On-Site Soil Sampling Summary Data, Pond Soils (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Thallium (Tl)	2.9 J	37	SC-P2-03 surface composite/ dredge	Apr-89	32/42	4	child-RMEG	31
Vanadium (V)	2.4	110	SC-SS-02 surface composite	Jan-88	39/42	200	child-I-EMEG	0
Zinc (Zn)	4.2	1,200 J	SC-SS-03, SC-SS-04 surface composites	Jan-88	41/42	20,000	child-C-EMEG	0
Inorganics-Other								
Chloride	47.2	1,190	51-4-5C composite depths	Dec-89	10/19	NA	NA	NA
Cyanide	0.86	12.6	45-1C composite depths	Dec-89	9/44	1,000	child-RMEG	0
Fluoride	5	410,000 J	SB-02SZ saturated zone	Jan-88	32/32	3,000	child-RMEG, FNa	4
Phosphorus (Total)	343	121,000	SS69 surface	Sept-90	27/27	NA	NA	NA

Table 2. On-Site Soil Sampling Summary Data, Pond Soils (continued)

Radiologic Parameters	Minimum (Bq/kg)	Confidence	Maximum (Bq/kg)	Confidence	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
								Value (Bq/kg)	Source	
Radium-226	14.8	±3.7	1,258	±111	44A-1C, 45-1C composite depths	Dec-89	30/32	5.4	NCRP screening limit (residential)	30

Sources:

NUS 1989 (one sampling point analyzed for VOCs and SVOCs, eight sampling points analyzed for metals and other inorganics).

NUS 1991 (27 sampling points analyzed for metals, 12 sampling points analyzed for other inorganics).

PBS&J 1990 (three samples analyzed for radium-226).

Weston 1990a (17 samples analyzed for metals and other inorganics, 29 samples analyzed for radium-226).

Weston 1990c (two sampling points analyzed for VOCs, SVOCs, pesticides, metals and other inorganics).

Weston 1993 (five samples analyzed for VOCs, SVOCs, pesticides, metals, and other inorganics).

Key:

B detected in the associated laboratory blank and in the sample

Bq/kg Becquerel per kilogram

CRDL contract-required detection limit

CREG cancer risk evaluation guide

C-EMEG chronic environmental media evaluation guide (ATSDR)

EPA AL U.S. Environmental Protection Agency action level

I-EMEG intermediate environmental media evaluation guide (ATSDR)

J estimated quantity below the quantitation limit

N presumptive evidence of presence of material

NCRP National Council on Radiation Protection and Measurements

NA not available

ppm parts per million

RBC-C risk-based concentration, for cancer effects

RBC-N risk-based concentration, for noncancer effects

RMEG reference dose media evaluation guide

X result is less than the CRDL, but greater than or equal to the instrument detection limit

Table 3. On-Site Soil Sampling Summary Data, Slag

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Volatile Organic Compounds (VOCs)								
No VOCs were detected in the on-site slag sample.								
Semivolatile Organic Compounds (SVOCs)								
Benzo[a]anthracene	0.12 J	0.12 J	SS93-14	Mar-93	1/1	0.87	RBC-C	0
Benzo[a]pyrene	0.11 J	0.11 J	SS93-14	Mar-93	1/1	0.1	CREG	1
Benzo[b]fluoranthene	0.17 J	0.17 J	SS93-14	Mar-93	1/1	0.87	RBC-C	0
Benzo[g,h,i]perylene	0.16 J	0.16 J	SS93-14	Mar-93	1/1	20,000	child-RMEG, anthracene	0
Benzo[k]fluoranthene	0.042 J	0.042 J	SS93-14	Mar-93	1/1	8.7	RBC-C	0
Chrysene	0.1 J	0.1 J	SS93-14	Mar-93	1/1	87	RBC-C	0
di-n-Butyl phthalate	0.19 J, B	0.19 J, B	SS93-14	Mar-93	1/1	5,000	child-RMEG	0
Fluoranthene	0.11 J	0.11 J	SS93-14	Mar-93	1/1	2,000	child-RMEG	0
Indeno[1,2,3-cd]pyrene	0.11 J	0.11 J	SS93-14	Mar-93	1/1	0.87	RBC-C	0
Phenanthrene	0.067 J	0.067 J	SS93-14	Mar-93	1/1	2,000	child-RMEG, fluoranthene	0
Pyrene	0.12 J	0.12 J	SS93-14	Mar-93	1/1	2,000	child-RMEG	0
Pesticides/Polychlorinated Biphenyls (PCBs)								
alpha-Chlordane	0.0015 J	0.0015 J	SS93-14	Mar-93	1/1	2	CREG	0
Dieldrin	0.0051	0.0051	SS93-14	Mar-93	1/1	0.04	CREG	0
gamma-Chlordane	0.0062	0.0062	SS93-14	Mar-93	1/1	2	CREG	0

Table 3. On-Site Soil Sampling Summary Data, Slag (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
p,p-DDT	0.0073	0.0073	SS93-14	Mar-93	1/1	2	CREG	0
Inorganics-Metals								
Aluminum (Al)	2,000	12,000	"Stauffer slag pile"	Jul-98	5/5	100,000	child-I-EMEG	0
Antimony (Sb)	0.0197	0.0197	"Stauffer slag pile"	Jul-98	1/5	20	child-RMEG	0
Arsenic (As)	0.00463	4.2	SS93-14	Mar-93	2/11	0.5	CREG	1
Barium (Ba)	32.8	108	"Stauffer slag pile"	Jul-98	2/2	4,000	child-RMEG	0
Beryllium (Be)	0.25 X	1.99	"Stauffer slag pile"	Jul-98	3/5	50	child-C-EMEG	0
Cadmium (Cd)	0.157	4.8	SS7	Dec-89	6/11	10	child-C-EMEG	0
Calcium (Ca)	49,500	49,500	SS93-14	Mar-93	1/1	NA	NA	NA
Chromium (Cr)	3.6	122	SS6	Dec-89	11/11	200	child-RMEG, Cr ⁶⁺	0
Cobalt (Co)	0.957	2.7 X	SS93-14	Mar-93	2/2	500	child-I-EMEG	0
Copper (Cu)	3.16	23.4	SS93-14	Mar-93	3/5	3,100	RBC-N	0
Iron (Fe)	3,130	10,600	SS93-14	Mar-93	2/2	23,000	RBC-N	0
Lead (Pb)	0.52	121	SS93-14	Mar-93	8/11	400	EPA AL	0
Magnesium (Mg)	394 X	394 X	SS93-14	Mar-93	1/1	NA	NA	NA

Table 3. On-Site Soil Sampling Summary Data, Slag (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Manganese (Mn)	145	471	"Stauffer slag pile"	Jul-98	2/2	3,000	child-RMEG	0
Mercury (Hg)	0.0248	0.0248	"Stauffer slag pile"	Jul-98	1/5	20	child-RMEG, HgCl ₂	0
Nickel (Ni)	14.8	40	Slag/7-7"	Sept-97	3/5	1,000	child-RMEG	0
Potassium (K)	278 X	278 X	SS93-14	Mar-93	1/1	NA	NA	NA
Selenium (Se)	0.33 X	0.414	"Stauffer slag pile"	Jul-98	2/5	300	child-C-EMEG	0
Silver (Ag)	0.00141	0.00141	"Stauffer slag pile"	Jul-98	1/5	300	child-RMEG	0
Sodium (Na)	582 X	582 X	SS93-14	Mar-93	1/1	NA	NA	NA
Thallium (Tl)	0.47	0.57 X	SS93-14	Mar-93	2/5	4	child-RMEG	0
Vanadium (V)	28.7	29.6	SS93-14	Mar-93	2/2	200	child-I-EMEG	0
Zinc (Zn)	6.7	186	SS93-14	Mar-93	4/5	20,000	child-C-EMEG	0
Inorganics-Other								
Cyanide	2	6.5	SS54	Apr-90	7/10	1,000	child-RMEG	0
Fluoride	30	1,920	SS54	Apr-90	11/11	3,000	child-RMEG, FNa	0
Phosphorus (Total)	1,610	48,500	SS6	Dec-89	10/10	NA	NA	NA

Table 3. On-Site Soil Sampling Summary Data, Slag (continued)

Radiologic Parameters	Minimum (Bq/kg)	Confidence	Maximum (Bq/kg)	Confidence	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
								Value (Bq/kg)	Source	
Gross alpha	9,990	±655	9,990	±655	Slag/2-6"	Sept-97	1/1	NA	NA	NA
Gross beta	4,590	±264	4,590	±264	Slag/2-6"	Sept-97	1/1	NA	NA	NA
Radium-226	777	±74	2,730	NA	SS48	Mar-90	12/12	5.4	NCRP screening limit (residential)	12

Sources:

PBS&J 1990 (one sampling point analyzed for radium-226).

Parsons 1997 (three sampling points analyzed for metals, other inorganics, and radionuclides).

EPA 1999a (one sampling point analyzed for metals, other inorganics, and radium-226).

Weston 1990a (six sampling points analyzed for metals and other inorganics; seven samples analyzed for radium-226).

Weston 1993 (one sampling point analyzed for VOCs, SVOCs, pesticides, PCBs, metals, and other inorganics).

Key:

B	detected in the associated laboratory blank and in the sample
Bq/kg	Becquerel per kilogram
CRDL	contract-required detection limit
CREG	cancer risk evaluation guide
C-EMEG	chronic environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
EPA AL	U.S. Environmental Protection Agency action level
I-EMEG	intermediate environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
J	estimated quantity below the quantitation limit
NA	not available
ppm	parts per million
RBC-C	risk-based concentration, for cancer effects
RBC-N	risk-based concentration, for noncancer effects
RMEG	reference dose media evaluation guide
X	result is less than the CRDL, but greater than or equal to the instrument detection limit

Table 4. On-Site Soil Sampling Data, Surface Soil

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Volatile Organic Compounds (VOCs)								
1,1,1-Trichloroethane	0.003 J	0.003 J	SS64	Apr-90	1/21	22,000	RBC-N	0
Acetone	0.005 J,B	0.66 E,B	SS66	Apr-90	11/21	20,000	child-RMEG	0
Bromoform	0.002 J	0.002 J	SS37C	Dec-89	1/21	90	CREG	0
Carbon disulfide	0.003 J	0.15	SS64 & SS66	Apr-90	7/22	5,000	child-RMEG	0
Chloroform	0.001 J	0.002 J	SS63 & SS65	Apr-90	3/22	100	CREG	0
Chloromethane	0.001 J	0.003 J	SS65	Apr-90	2/21	49	RBC-C	0
Ethylbenzene	0.001 J	0.001 J	SS38C	Dec-89	1/21	5,000	child-RMEG	0
Methylene chloride	0.005 B	0.48 E,B	SS64	Apr-90	17/21	90	CREG	0
Tetrachloroethylene	0.001 J	0.007	SS64 & SS66	Apr-90	9/21	500	child-RMEG	0
Toluene	0.002 J	0.041	SS66	Apr-90	9/22	1,000	child-I-EMEG	0
Semivolatile Organic Compounds (SVOCs)								
1,2-Dichlorobenzene	0.012 T,C	0.012 T,C	SS37C	Dec-89	1/23	5,000	child-RMEG	0
1,3-Dichlorobenzene	0.0056 T,C	0.0056 T,C	SS37C	Dec-89	1/23	2,300	RBC-N	0
1,4-Dichlorobenzene	0.0069 T,C	0.0069 T,C	SS37C	Dec-89	1/23	20,000	child-I-EMEG	0
2-Methylnaphthalene	0.045 J	0.077 J	SS93-10	Mar-93	3/23	2,000	RBC-N	0
2,4-Dichlorophenol	0.057 J	1.2	SS34C	Dec-89	3/23	200	child-I-EMEG	0
2,4,5-Trichlorophenol	0.17 J	0.17 J	SS34C	Dec-89	1/23	5,000	child-RMEG	0
2,4,6-Trichlorophenol	0.29 J	0.29 J	SS34C	Dec-89	1/23	60	CREG	0

Table 4. On-Site Soil Sampling Data, Surface Soil (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Acenaphthylene	0.11 J	0.77	SS93-1	Mar-93	3/23	4,700	RBC-N	0
Anthracene	0.008 J	1.0	SS93-1	Mar-93	5/23	20,000	child-RMEG	0
Benzo[a]anthracene	0.056 J	2.9	SS93-10	Mar-93	10/24	0.87	RBC-C	4
Benzo[a]pyrene	0.025 J	2.7	SS65	Apr-90	11/24	0.1	CREG	6
Benzo[b]fluoranthene	0.051 J	4.3	SS93-1	Mar-93	13/24	0.87	RBC-C	4
Benzo[g,h,i]perylene	0.045 J	3.5	SS65	Apr-90	10/23	20,000	child-RMEG, anthracene	0
Benzo[k]fluoranthene	0.034 J	2.6	SS65	Apr-90	11/24	8.7	RBC-C	0
Benzoic acid	0.14 J,B	0.51 J,B	SS36C	Dec-89	8/16	200,000	child-RMEG	0
bis(2-Ethylhexyl) phthalate	0.043 J,B	1.0 J,B	SS65	Apr-90	9/23	50	CREG	0
Carbazole	0.084 J	0.57	SS93-10	Mar-93	3/7	32	RBC-C	0
Chrysene	0.042 J	2.8	SS65	Apr-90	13/24	87	RBC-C	0
di-n-Butyl phthalate	0.054 J	0.24 J,B	SS93-13	Mar-93	13/23	5,000	child-RMEG	0
Dibenzo[a,h] anthracene	0.1 J	0.34 J	SS93-1	Mar-93	3/23	0.087	RBC-C	3
Dibenzofuran	0.038 J	0.067 J	SS93-10	Mar-93	2/23	310	RBC-N	0
Fluoranthene	0.055 J	3.3	SS93-10	Mar-93	12/24	2,000	child-RMEG	0
Fluorene	0.066 J	0.075 J	SS93-1	Mar-93	2/23	2,000	child-RMEG	0
Indeno[1,2,3-cd] pyrene	0.060 J	3.1	SS65	Apr-90	10/23	0.87	RBC-C	3
Isophorone	0.24 J	0.33 J	SS66	Apr-90	2/23	700	CREG	0

Table 4. On-Site Soil Sampling Data, Surface Soil (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Naphthalene	0.048 J	0.049 J	SS93-10	Mar-93	2/23	1,000	child-I-EMEG child-RMEG	0
Phenanthrene	0.036 J	1.5	SS93-10	Mar-93	9/23	2,000	child-RMEG, fluoranthene	0
Phenol	0.006 T,J	0.01 T,J	SS64	Apr-90	2/23	30,000	child-RMEG	0
Pyrene	0.040 J	3.1	SS93-10	Mar-93	13/23	2,000	child-RMEG	0
Pesticides/Polychlorinated Biphenyls (PCBs)								
Arochlor-1254	0.21 J	0.21 J	SS65	Apr-90	1/28	1	child-C-EMEG	0
Arochlor-1260	0.076 J	0.076 J	SS64	Apr-90	1/28	0.32	RBC-C	0
Dieldrin	0.02	0.027	SS93-9A	Mar-93	2/28	0.04	CREG	0
pp-DDE	0.009	0.021	SS93-9A	Mar-93	2/28	2	CREG	0
pp-DDT	0.0038 J,B	0.013	SS51C	Apr-90	6/28	2	CREG	0
Inorganics-Metals								
Aluminum (Al)	67.4	6,810	SS93-8	Mar-93	23/23	100,000	child-I-EMEG	0
Antimony (Sb)	0.91 B	48.9	SS93-6	Mar-93	10/21	20	child-RMEG	4
Arsenic (As)	0.39 J	140	NE-1-6"	Sept-97	32/91	0.5	CREG	30
Barium (Ba)	2.4 X	80.9	SS93-3	Mar-93	14/15	4,000	child-RMEG	0
Beryllium (Be)	0.05 B	1.6	SS93-8	Mar-93	30/39	50	child-C-EMEG	0
Cadmium (Cd)	0.82 X	59	NE-1-6"	Sept-97	45/73	10	child-C-EMEG	7
Calcium (Ca)	36 X	377,000	SS93-8	Mar-93	16/17	NA	NA	NA

Table 4. On-Site Soil Sampling Data, Surface Soil (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Chromium (Cr)	0.58 B	163	SS93-3	Mar-93	64/75	200	child-RMEG	0
Cobalt (Co)	1.1	33.3	SS93-5	Mar-93	10/15	500	child-I-EMEG	0
Copper (Cu)	0.34 B	65.5	SS93-5	Mar-93	19/21	3,100	RBC-N	0
Iron (Fe)	250	44,800	SS93-3	Mar-93	17/17	23,000	RBC-N	2
Lead (Pb)	0.7	324	SS93-8	Mar-93	75/75	400	EPA AL	0
Magnesium (Mg)	34	3,910	SS93-21	Jul-93	15/15	NA	NA	NA
Manganese (Mn)	0.59 X	292	SS93-3	Mar-93	17/17	3,000	child-RMEG	0
Mercury (Hg)	0.066	0.67	NE-1-6"	Sept-97	5/21	20	child-RMEG, HgCl ₂	0
Nickel (Ni)	0.91 B	115	SS93-5	Mar-93	19/21	1,000	child-RMEG	0
Potassium (K)	161 X	1,740	SS93-6	Mar-93	12/15	NA	NA	NA
Selenium (Se)	0.32	32.5	SS93-8	Mar-93	13/21	300	child-C-EMEG	0
Silver (Ag)	1.2 X	9.7	SS93-8	Mar-93	5/21	300	child-RMEG	0
Sodium (Na)	19.6 X	15,500	SS93-21	Jul-93	14/15	NA	NA	NA
Thallium (Tl)	0.37 X	15	NE-1-6"	Sept-97	9/21	4	child-RMEG	4
Vanadium (V)	1.4 X	252	SS93-5	Mar-93	15/15	200	child-I-EMEG	1
Zinc (Zn)	0.9 B	519	SS93-8	Mar-93	20/21	20,000	child-C-EMEG	0
Inorganics-Other								
Chloride	47.3	224	SS16	Dec-89	3/52	NA	NA	NA

Table 4. On-Site Soil Sampling Data, Surface Soil (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Cyanide	0.57	3.0	SS1	Dec-89	4/73	1,000	child-RMEG	0
Fluoride	3.1	4,230	SS17	Dec-89	75/77	3,000	child-C-EMEG, FNa	1
Phosphorus (total)	50	84,800	SS10	Dec-89	76/76	NA	NA	NA

Radiologic Parameters	Minimum (Bq/kg)	Confidence	Maximum (Bq/kg)	Confidence	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
								Value (Bq/kg)	Source	
Gross alpha	77.0 J	±21.4	29,800	540	NE-1-6"	Sept-97	6/7	NA	NA	NA
Gross beta	67.0 J	±26.2	17,800	233	NE-1-6"	Sept-97	6/7	NA	NA	NA
Polonium-210	7,522	NA	7,522	NA	SS93-21	Mar-93	1/1	210	NCRP screening limit (residential)	1
Radium-226	12.6 J	±3.62	1,813	±185	SS29	Dec-89	39/39	5.4	NCRP screening limit (residential)	39
Radon-222	110	NA	110	NA	SS93-21	Mar-93	1/1	NA	NA	NA

Sources: NUS 1989 (one sampling point analyzed for VOCs and SVOCs, metals, and other inorganics).
NUS 1991 (two sampling points analyzed for metals).
PBS&J 1990 (six sampling points analyzed for radium-226).
Parsons 1997 (six sampling points analyzed for metals, other inorganics, and radionuclides).
Parsons 1999 (18 samples analyzed for metals).

Table 4. On-Site Soil Sampling Data, Surface Soil (continued)

Weston 1990a (16 samples analyzed for VOCs, SVOCs, and pesticides/PCBs; 52 samples analyzed for metals and other inorganics; 23 samples analyzed for radium-226).

Weston 1990c (three samples analyzed for radionuclides).

Weston 1993 (7 samples analyzed for VOCs and SVOCs; 12 samples analyzed for pesticides/PCBs; 14 samples analyzed for metals; 18 samples analyzed for other inorganics; 1 sampling point analyzed for radionuclides).

On-site surface soil samples are those samples *not* taken from former ponds, dredge pond material, slag (from slag pits and storage area), or roads.

Key:

B	detected in the associated laboratory blank and in the sample
Bq/kg	Becquerel per kilogram
C	response factor from daily standard
CRDL	contract-required detection limit
CREG	cancer risk evaluation guide
C-EMEG	chronic environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
E	compound was detected beyond the calibration range and was subsequently analyzed at dilution
I-EMEG	intermediate environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
J	estimated quantity below the quantitation limit
NA	not available
NCRP	National Council on Radiation Protection and Measurements
ppm	parts per million
RBC-C	risk-based concentration, for cancer effects
RBC-N	risk-based concentration, for noncancer effects
RMEG	reference dose media evaluation guide
T	compound tentatively identified by laboratory during analysis
X	result is less than the CRDL, but greater than or equal to the instrument detection limit

Table 5. On-Site Soil Sampling Summary Data, Surface Soil Contaminants of Potential Concern

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Mean Detected (ppm)	Median Detected (ppm)	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Inorganics-Metals								
Arsenic (As)	0.39 J	140	20	5.0	32/91	0.5	CREG	30
Cadmium (Cd)	0.82 X	59	8.0	2.3	45/73	10	child-C-EMEG	7
Thallium (Tl)	0.37 X	15	6.4	2.8	9/21	4	child-RMEG	4
Inorganics-Other								
Fluoride	3.1	4,230	474	206	75/77	3,000	child-C-EMEG, FNa	1
Phosphorus (Total)	50	84,800	24,600	16,900	76/76	NA	NA	NA

Sources: NUS 1989 (one sampling point analyzed for metals and other inorganics).

NUS 1991 (two sampling points analyzed for metals).

Parsons 1997 (six sampling points analyzed for metals and other inorganics).

Parsons 1999 (18 samples analyzed for metals).

Weston 1990a (52 samples analyzed for metals and other inorganics).

Weston 1993 (14 samples analyzed for metals and 18 samples analyzed for other inorganics).

On-site surface soil samples are those samples *not* taken from former ponds, dredge pond material, slag (from slag pits and storage area), or roads.

Key:

ppm	parts per million
CRDL	contract-required detection limit
CREG	cancer risk evaluation guide
C-EMEG	chronic environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
J	estimated quantity below the quantitation limit
NA	not available
RMEG	reference dose media evaluation guide
X	result is less than the CRDL, but greater than or equal to the instrument detection limit

Table 6. Stauffer Chemical Company Site, Monitoring Well Identifications (1985 to 2002)

Semiannual Sampling (NUS 1989, SMC 2002)	Expanded Site Investigation (NUS 1989)	Final Listing Site Inspection (NUS 1991)	Remedial Investigation (Weston 1993)		(Parsons 1999)	Description	
<i>January 1987 through February 2002</i>	<i>January 1988</i>	<i>April 1989</i>	<i>March/ April 1993</i>	<i>July 1993</i>	<i>1998 and 1999</i>	<i>Location</i>	<i>Approximate Depth (feet)</i>
M-1	SC-MW-04ES	SC-MW-04ES	MW-4ES	—	—	Downgradient of slag disposal area	16
M-2	SC-MW-08ES	SC-MW-08ES	MW-8ES	—	MW-8ES	Downgradient of lagoons/calcium fluoride storage areas	17
M-3	SC-MW-06ES	SC-MW-06ES	MW-6ES	—	—	Downgradient of lagoons/calcium fluoride storage areas	15
M-4	SC-MW-05ES	SC-MW-05ES	MW-5ES	—	—	Downgradient of lagoon no. 1	16
M-5	SC-MW-02ES	SC-MW-02ES	MW-2ES	—	—	Downgradient of calcium fluoride deposit	15
M-6	SC-MW-03ES	SC-MW-03ES	—	—	—	Downgradient of calcium fluoride deposit	15
M-7	SC-MW-07ES	SC-MW-07ES	MW-7ES	MW-7ES	MW-7ES	Background	18
—	SC-MW-01S	SC-MW-01S	MW-1S	MW-1S	MW-1S	Background	32
—	SC-MW-01F	SC-MW-01F	MW-1F	—	—	Background	50
—	SC-MW-02F	SC-MW-02F	MW-2F	—	—	Downgradient of lagoons/drum burial areas	50
—	SC-MW-03F	SC-MW-03F	MW-3F	—	—	Along east property line	50
—	SC-MW-04F	SC-MW-04F	MW-4F	—	—	South of Anclote River	50
—	SC-MW-07S	SC-MW-07S	MW-7S	—	—	Downgradient of lagoons/calcium fluoride storage areas	32
—	SC-MW-09S	SC-MW-09S	MW-9S	—	MW-9S	Downgradient of buried drum area (no. 3)	32

Table 6. Stauffer Chemical Company Site, Monitoring Well Identifications (1985 to 2002) (continued)

Semiannual Sampling (NUS 1989, SMC 2002)	Expanded Site Investigation (NUS 1989)	Final Listing Site Inspection (NUS 1991)	Remedial Investigation (Weston 1993)		(Parsons 1999)	Description	
<i>January 1987 through February 2002</i>	<i>January 1988</i>	<i>April 1989</i>	<i>March/ April 1993</i>	<i>July 1993</i>	<i>1998 and 1999</i>	<i>Location</i>	<i>Approximate Depth (feet)</i>
—	SC-MW-10S	SC-MW-10S	MW-10S	—	—	Along east property line	32
—	SC-MW-11S	SC-MW-11S	MW-11S	—	—	South of Anclote River	32
—	SC-TW-01	—	—	—	—	Background; northeast corner of the site	IBWT
—	SC-TW-03	—	—	—	—	South of Anclote Road and slag disposal area	IBWT
—	SC-TW-06	—	—	—	—	Old disposal pond near lagoon system	IBWT
—	SC-TW-07	—	—	—	—	Immediately southwest of buried drum area no. 1	IBWT
—	SC-TW-08	—	—	—	—	Downgradient of calcium fluoride storage area no. 3	IBWT
—	SC-TW-09	—	—	—	—	Southwest of drum disposal area no. 3	IBWT
—	SC-TW-11	—	—	—	—	Downgradient/west of facility complex	IBWT
—	SC-TW-13	—	—	—	—	Along east property boundary	IBWT
—	SC-TW-14	—	—	—	—	Along east property boundary	IBWT
—	SC-TW-16	—	—	—	—	Anclote River dredge disposal area	IBWT
—	—	—	MW93-1	—	—	Downgradient from former slag processing area	11

Table 6. Stauffer Chemical Company Site, Monitoring Well Identifications (1985 to 2002) (continued)

Semiannual Sampling (NUS 1989, SMC 2002)	Expanded Site Investigation (NUS 1989)	Final Listing Site Inspection (NUS 1991)	Remedial Investigation (Weston 1993)		(Parsons 1999)	Description	
January 1987 through February 2002	January 1988	April 1989	March/ April 1993	July 1993	1998 and 1999	Location	Approximate Depth (feet)
—	—	—	MW93-2	—	—	Just west of Anclole Road (to characterize possible upgradient/off-site sources)	16
—	—	—	MW93-3	—	—	South of pond 42	16
—	—	—	MW93-4	—	—	Central portion of site (to characterize impact of main process area)	20
—	—	—	MW93-5	—	MW93-5	North of pond 42	15
—	—	—	WP93-1	—	—	Temporary well point installed radially around MW-93-4	S
—	—	—	WP93-2	—	—	Temporary well point installed radially around MW-93-4	S
—	—	—	WP93-3	—	—	Temporary well point installed radially around MW-93-4	S
—	—	—	WP93-4	—	—	Temporary well point installed radially around MW-93-4	S
—	—	—	WP93-5	—	—	Temporary well point installed radially around MW-93-4	S
—	—	—	—	WP93-6	—	Piezometer installed to evaluate water table elevation near MW93-1	12
—	—	—	—	WP93-7	—	Piezometer installed to evaluate water table elevation near MW93-1	7
—	—	—	—	WP93-8	—	Piezometer installed to evaluate water table elevation near MW93-1	13

Table 6. Stauffer Chemical Company Site, Monitoring Well Identifications (1985 to 2002) (continued)

Semiannual Sampling (NUS 1989, SMC 2002)	Expanded Site Investigation (NUS 1989)	Final Listing Site Inspection (NUS 1991)	Remedial Investigation (Weston 1993)		(Parsons 1999)	Description	
<i>January 1987 through February 2002</i>	<i>January 1988</i>	<i>April 1989</i>	<i>March/ April 1993</i>	<i>July 1993</i>	<i>1998 and 1999</i>	<i>Location</i>	<i>Approximate Depth (feet)</i>
—	—	—	—	—	MW-98-1	North of site and north of Anclole Road at Sweetbriar Drive	S
—	—	—	—	—	MW-98-2	Downgradient along western boundary of site	S
—	—	—	—	—	MW-98-3	Downgradient along western boundary of site	S
—	—	—	—	—	MW-98-4	Downgradient along western boundary of site	S

Key

IBWT immediately below water table
 MW monitoring well
 S shallow
 SI site inspection
 TW temporary well

Table 7. On-Site Groundwater Monitoring Summary Data, Surficial Aquifer

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppb)	Source	
Volatile Organic Compounds (VOCs)								
Carbon Disulfide	4 J	4 J	MW-8ES	Jan-88	1/4	1,000	child-RMEG	0
Chloroform	6	6	MW-9S	Jan-88	1/5	6	CREG	0
1,1-Dichloroethane	2 J	2 J	MW-8ES	Jan-88	1/5	800	RBC-N	0
Trichloroethylene	14	14	MW-1S	Mar-93	1/7	0.09	CREG	1
Semivolatile Organic Compounds (SVOCs)								
Di-n-Octyl Phthalate	0.80 J	1 J	MW93-3	Mar-93	2/7	730	RBC-N	0
4-Methylphenol	1 J	1 J	MW93-1	Mar-93	1/7	180	RBC-N	0
Pesticides/Polychlorinated Biphenyls								
Methoxychlor	0.009 J,P	0.009 J,P	MW93-3	Mar-93	1/8	40	LTHA, MCL, MCLG	0
Inorganics-Metals								
Aluminum (Al)	19.8 B	290,000	MW-11S	Jan-88	286/379	37,000	RBC-N	13
Antimony (Sb)	2	210	MW-8ES	Oct-88	63/370	4	child-RMEG	41
Arsenic (As)	1	980	MW93-3	Mar-93	199/382	0.02	CREG	199
Barium (Ba)	1	550	MW93-3	Mar-93	158/370	700	child-RMEG	0
Beryllium (Be)	0.11 B	11	MW-11S	Jan-88	14/83	20	child-RMEG	0
Boron (B)	25	3,200	MW-7ES	Jul-92	204/284	600	LTHA	44
Cadmium (Cd)	0.00	150	MW93-3	Mar-93	33/95	5	child-RMEG, LTHA	11

Table 7. On-Site Groundwater Monitoring Summary Data, Surficial Aquifer (continued)

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppb)	Source	
Calcium (Ca)	5,800	2,300,000	MW-3ES	Jan-88	95/95	NA	NA	–
Chromium (Cr)	0.72 B	700	MW-11S	Jan-88	72/379	30	child-RMEG	28
Cobalt (Co)	3	47	MW-11S	Jan-88	7/83	730	RBC-N	0
Copper (Cu)	1	260	MW93-3	Mar-93	35/95	1,300	MCLG	0
Iron (Fe)	0.00	130,000	MW-11S	Jan-88	343/382	11,000	RBC-N	14
Lead (Pb)	1.1 X	680	MW93-3	Mar-93	29/82	15	EPA AL	10
Lithium (Li)	10	1,000	MW-5ES	Jul-90	50/284	730	RBC-N	2
Magnesium (Mg)	650	130,000	MW-8ES	Dec-98	91/95	NA	NA	–
Manganese (Mn)	1	1,700	MW-3ES	Jan-88	283/382	500	child-RMEG	3
Mercury (Hg)	0.02	5.9	MW93-3	Mar-93	13/55	2	LTHA (Inorganic Hg)	1
Nickel (Ni)	1	240	MW-11S	Jan-88	65/370	100	LTHA	3
Potassium (K)	302 B	480,000	MW-8ES	Jun-99	84/95	NA	NA	–
Selenium (Se)	1.4 X	140	MW93-3	Mar-93	14/83	50	child RMEG, LTHA	1
Silver (Ag)	4.3	6.3	MW93-3	Mar-93	2/43	50	child-RMEG	0
Sodium (Na)	2,100	690,000	MW-7S	Jan-88	95/95	NA	NA	–
Thallium (Tl)	3 JN	240	MW-9S	Mar-93	11/83	0.5	LTHA	11
Vanadium (V)	1 B	360	MW-11S	Jan-88	47/83	260	RBC-N	6
Zinc (Zn)	1.5 B	1,700	MW93-3	Mar-93	42/83	2,000	LTHA	0

Table 7. On-Site Groundwater Monitoring Summary Data, Surficial Aquifer (continued)

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppb)	Source	
Inorganics-Other								
Cyanide	2.2 B	160	MW-7ES	Jun-99	11/72	200	child-RMEG, LTHA	0
Fluoride	120	71,000 J	MW-3ES	Jan-88	348/358	4,000	MCL	139
Ortho-P	0.00	72,000	MW-8ES	Jul-96	237/273			
Phosphorus (Elemental)	0.17	0.43	MW-98-4	Sep-98	3/40			
Phosphorus (Total)	25	380,000	MW-8ES	Sep-98	73/75			
Sulfate (SO ₄)	1,000	2,400,000	MW-7ES	Jul-92	267/274	250,000	NSDWRs	75

Radiologic Parameters	Minimum (pCi/L)	Confidence	Maximum (pCi/L)	Confidence	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
								Value (pCi/L)	Source	
Gross Alpha	-22.0000	±12.0	366.3	NA	MW93-3	Mar-93	270/363	15	MCL	41
Gross Beta	0.4000	±0.9	689.5	NA	MW93-3	Mar-93	321/362			
Polonium-210	-1	±6	314.9	NA	MW93-3	Mar-93	128/341			
Radium-226	-0.4000	±0.4	15.4	NA	MW-7S	Mar-93	228/341	5	MCL	7
Radon-222	-33.6	169.76 %	11,600.0	±300	MW-3ES	Jan-90	347/363	300	MCL	171

Sources: Flow 2001; NUS Corp 1989, 1991; Parsons 1999; SMC 2002; Weston 1993.

Table 7. On-Site Groundwater Monitoring Summary Data, Surficial Aquifer (continued)

Key:

B	Detected in the associated laboratory blank and in the sample
CREG	cancer risk evaluation guide
EPA AL	U.S. Environmental Protection Agency action level
J	estimated quantity below the quantitation limit
LTHA	lifetime health advisory (U.S. Environmental Protection Agency)
MCL	maximum contaminant level (U.S. Environmental Protection Agency)
MCLG	maximum contaminant level goal (U.S. Environmental Protection Agency)
NA	not available
NSDWRs	National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency)
P	the percent difference between the results from the two gas chromatograph columns is > 25%; the lower of the two is reported
pCi/L	picocuries per liter
ppb	parts per billion
RBC-N	risk-based concentration, for noncancer effects
RMEG	reference dose media evaluation guide
X	result in less than the contract required detection limit, but greater than or equal to the instrument detection limit

Notes:

- Negative radiological readings represent samples in which the amount of radioactivity in the sample blank was larger than that in the sample.
- Stauffer Management Company duplicate samples collected during its routine groundwater monitoring program were counted as individual samples.

Table 8. On-Site Groundwater Monitoring Summary Data, Floridan Aquifer

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppb)	Source	
Volatile Organic Compounds (VOCs)								
Chloroform	1 J	1 J	MW-2F	Jan-88	1/3	6	CREG	0
Dibromochloromethane	1 J	1 J	MW-2F	Jan-88	1/3	0.13	RBC-C	1
1,1-Dichloroethane	1 J	1 J	MW-2F	Jan-88	1/3	800	RBC-N	0
Methylethyl Ketone	78 J,N	78 J,N	MW-1F	Jan-88	1/3	1900	RBC-N	0
Pesticides/Polychlorinated Biphenyls (PCBs)								
Methoxychlor	0.003 J,P	0.003 J,P	MW-2F	Mar-93	½	40	LTHA, MCL, MCLG	0
Inorganics-Metals								
Aluminum (Al)	34	74,000	MW-4F	Jan-88	8/8	37,000	RBC-N	1
Arsenic (As)	1.6	110 J,N	MW-4F	Jan-88	6/12	0.02	CREG	6
Barium (Ba)	10	340 J	MW-4F	Jan-88	8/8	700	child-RMEG	0
Beryllium (Be)	5	5	MW-4F	Jan-88	1/8	20	child-RMEG	0
Cadmium (Cd)	0.2	29	MW-3F	Jan-88	5/8	5	child-RMEG, LTHA	1
Calcium (Ca)	7,600	710,000	MW-4F	Jan-88	12/12	NA		
Chromium (Cr)	5.6	290	MW-4F	Jan-88	3/8	30	child-RMEG	1
Cobalt (Co)	35	35	MW-4F	Jan-88	1/8	730	RBC-N	0

Table 8. On-Site Groundwater Monitoring Summary Data, Floridan Aquifer (continued)

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppb)	Source	
Copper (Cu)	1.6	320	MW-3F	Jan-88	6/8	1,300	MCLG	0
Iron (Fe)	39	110,000	MW-4F	Jan-88	11/11	11,000	RBC-N	1
Lead (Pb)	1.6	9.6	MW-4F	Mar-93	2/8	15	EPA AL	0
Magnesium (Mg)	2,300 X	210,000	MW-4F	Jan-88	11/12	NA		
Manganese (Mn)	12	5,200	MW-4F	Jan-88	11/12	500	child-RMEG	1
Nickel (Ni)	12	200	MW-4F	Jan-88	3/8	100	LTHA	1
Potassium (K)	2,300	62,000	MW-2F	Apr-89	9/12	NA		
Sodium (Na)	11,900	690,000	MW-2F	Jan-88	12/12	NA		
Thallium (Tl)	2 J,N	2 J,N	MW-3F	Jan-88	1/8	0.5	LTHA	1
Vanadium (V)	4.1	320	MW-4F	Jan-88	5/8	260	RBC-N	1
Zinc (Zn)	12 X	210	MW-4F	Jan-88	5/8	2,000	LTHA	0
Inorganics-Other								
Fluoride	190	300	MW-2F	Mar-93	2/8	4,000	MCL	0
Phosphorus (Total)	93	27,000 J	MW-4F	Jan-88	5/7			

Table 8. On-Site Groundwater Monitoring Summary Data, Floridan Aquifer (continued)

Radiologic Parameters	Minimum (pCi/L)	Confidence	Maximum (pCi/L)	Confidence	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
								Value (pCi/L)	Source	
Gross Alpha	-3	±6	140	±30	MW-4F	Jan-88	8/8	15	MCL	2
Gross Beta	4	±1.5	113	±13	MW-4F	Jan-88	8/8			
Polonium-210	0.57	NA	1.7	NA	MW-4F	Mar-93	2/4			
Radium-226	0.66	NA	1.7	NA	MW-2F	Mar-93	3/4	5	MCL	0
Radon-222	10.3	NA	2,536	2.98 %	MW-1F	Jan-88	18/18	300	MCL	17

Sources: Flow 2001; NUS Corp 1989, 1991; Parsons 1999; SMC 2002; Weston 1993.

Key:

CREG	cancer risk evaluation guide
EPA AL	U.S. Environmental Protection Agency action level
J	estimated quantity below the quantitation limit
LTHA	lifetime health advisory (U.S. Environmental Protection Agency)
MCL	maximum contaminant level (U.S. Environmental Protection Agency)
MCLG	maximum contaminant level goal (U.S. Environmental Protection Agency)
N	presumptive evidence of presence of material
NSDWRs	National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency)
P	the percent difference between the results from the two gas chromatograph columns is > 25%; the lower of the two is reported
ppb	parts per billion
RBC-C	risk-based concentration, for cancer effects
RBC-N	risk-based concentration, for noncancer effects
RMEG	reference dose media evaluation guide
X	result in less than the contract required detection limit, but greater than or equal to the instrument detection limit

Notes:

- Negative radiologic readings represent samples in which the amount of radioactivity in the sample blank was larger than that in the sample.

Table 9. Maximum Contaminant Levels Detected in Potable Water Wells (Wells 5, 12, 13, and 15) at Stauffer Chemical Company, Tarpon Springs, Florida, Before 1979 (When Use of These Wells Ceased)

Contaminant	Minimum Detected	Maximum Detected	Location of Maximum	Date of Maximum	Comparison Value (CV)	
					Value	Source
Fluoride	50 ppb	350 ppb	Well 5	6/11/74	4,000 ppb	MCL
Phosphorus	ND	2,240 ppb	Well 15	10/30/78	0.1 ppb*	LTHA
Sulfate	<5,000 ppb	80,000 ppb	Well 15	8/31/77	250,000 ppb	NSDWR
Iron	ND	600 ppb	Well 15	10/30/78	11,000 ppb	EPA RBC

Table 10. Maximum Contaminant Levels Detected in Backup Potable Water Wells (Wells 7, 10, and 14) at Stauffer Chemical Company, Tarpon Springs, Florida, Before 1979 (When Use of Potable Wells Ceased)

Contaminant	Minimum Detected	Maximum Detected	Location of Maximum	Date of Maximum	Comparison Value (CV)	
					Value	Source
Fluoride	100 ppb	1,340 ppb	Well 10	5/20/74	4,000 ppb	MCL
Phosphorus	60 ppb	2,020 ppb	Well 10	10/30/78	0.1 ppb*	LTHA
Sulfate	10,000 ppb	307,000 ppb	Well 10	3/30/77	250,000 ppb	NSDWR
Iron	<50 ppb	4,000 ppb	Well 14	3/30/77	11,000 ppb	EPA RBC

Key:

EPA U.S. Environmental Protection Agency
 LTHA lifetime health advisory for drinking water (EPA)
 MCL maximum contaminant level (EPA)
 ND not detected
 NSDWR National Secondary Drinking Water Regulations (EPA)
 ppb parts per billion
 RBC risk-based concentration

Note:

*CV is for elemental (white) phosphorus.

Table 11. Off-Site Soil Monitoring Summary Data, Gulfside Elementary School Surface Soils

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Volatile Organic Compounds (VOCs)								
No GES samples were analyzed for VOCs.								
Semivolatile Organic Compounds (SVOCs)								
No GES samples were analyzed for SVOCs.								
Pesticides/Polychlorinated Biphenyls (PCBs)								
No GES samples were analyzed for pesticides/PCBs.								
Inorganics-Metals								
Aluminum (Al)	310	5,760	SC96-9	Feb-96	16/16	100,000	child-I-EMEG	0
Antimony (Sb)	1.7	13.2	SC93-1	Jul-93	3/14	20	child-RMEG	0
Arsenic (As)	0.13	0.6	SC93-1	Jul-93	9/14	0.5	CREG	1
Barium (Ba)	1.5	14.8	SC93-1	Jul-93	14/14	4,000	child-RMEG	0
Beryllium (Be)	0.16	0.16	SC93-1	Jul-93	2/14	50	child-C-EMEG	0
Cadmium (Cd)	0.59	0.59	SC93-1	Jul-93	1/14	10	child-C-EMEG	0
Calcium (Ca)	251	16,400	SC93-1	Jul-93	15/16	NA	NA	NA
Chromium (Cr)	0.83	23.9	SC93-1	Jul-93	16/16	200	child-RMEG	0
Cobalt (Co)	0.29	0.38	SC96-9	Feb-96	3/14	500	child-I-EMEG	0
Copper (Cu)	0.27	4.8	SC96-9	Feb-96	10/14	3,100	RBC-N	0
Iron (Fe)	220	1,430	SC93-1	Jul-93	16/16	23,000	RBC-N	0

Table 11. Off-Site Soil Monitoring Summary Data, Gulfside Elementary School Surface Soils (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppm)	Source	
Lead (Pb)	1.2	6.3	SC93-3	Jul-93	15/16	400	EPA AL	0
Magnesium (Mg)	19.6	634	SC93-1	Jul-93	14/14	NA	NA	NA
Manganese (Mn)	6.0	22.9	SC96-3	Feb-96	16/16	3,000	child-RMEG	0
Nickel (Ni)	1.1	4.2	SC93-3	Jul-93	13/14	1,000	child-RMEG	0
Potassium (K)	66.7	265	SC93-1	Jul-93	7/14	NA	NA	NA
Selenium (Se)	0.12	0.35	SC93-3	Jul-93	7/14	300	child-C-EMEG	0
Sodium (Na)	7.2	57.1	SC93-1	Jul-93	14/14	NA	NA	NA
Vanadium (V)	2.4	17.2	SC93-1	Jul-93	14/14	200	child-I-EMEG	0
Zinc (Zn)	1.2	16	SC96-8	Feb-96	14/14	20,000	child-C-EMEG	0
Inorganics-Other								
Cyanide	0.85	0.85	SC96-2	Feb-96	1/14	1,000	child-RMEG	0
Fluoride	2.4	14.3	SC93-1	Jul-93	4/14	3,000	child-C-EMEG, FNa	0
ortho-Phosphorus	6.9	7.3	S-2	Aug-97	2/14	NA	NA	NA
Phosphorus (Total)	5.4	1,100	SC93-1	Jul-93	27/28	NA	NA	NA

Table 11. Off-Site Soil Monitoring Summary Data, Gulfside Elementary School Surface Soils (continued)

Radiologic Parameters	Minimum (Bq/kg)	Confidence	Maximum (Bq/kg)	Confidence	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
								Value (Bq/kg)	Source	
Gross Alpha	27.4	± 201	740	NA	SC93-1	Jul-93	15/15	NA	NA	NA
Gross Beta	7.03	± 246	1,050	NA	SC93-1	Jul-93	15/15	NA	NA	NA
Polonium-210	10	± 7.0	107	NA	SC93-1	Jul-93	16/16	210	NCRP screening limit (residential)	0
Radium-226	15.5	NA	59.2	NA	SC93-1	Jul-93	15/15	5.4	NCRP screening limit (residential)	15
Radon-222	4.4	± 1.8	59	NA	SS93-1	Jul-93	15/15	NA	NA	NA

NOTE: One additional radiologic sampling was performed on roadways bordering GES on the east and northeast, as well as on the roofing material (EE&G 1997a). All parameters were below or within the ranges of the surface soil samples listed above. The concentrations of radium-266 found in both samples were above the comparison value.

Sources: EE&G 1997a (14 sampling points analyzed for other inorganics); NUS 1991 (two sampling points analyzed for metals); Weston 1993 (four sampling points analyzed for radionuclides, metals, and other inorganics); Weston 1996 (10 sampling points analyzed for metals and other inorganics, 12 sampling points analyzed for radionuclides.)

Key: Bq/kg Becquerel per kilogram
 CREG cancer risk evaluation guide
 C-EMEG chronic environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
 EPA AL U.S. Environmental Protection Agency action level
 GES Gulfside Elementary School
 I-EMEG intermediate environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
 NA not available
 NCRP National Council on Radiation Protection and Measurements
 ppm parts per million
 RBC-N risk-based concentration, for noncancer effects
 RMEG reference dose media evaluation guide

Table 12. Private well sample locations and dates sampled

Map No.	Address	Well Type	Sampling Events (No.)	Year
1	1151 Savannah Avenue	Residential-potable	2	1999, 2000
2	1503 Savannah Avenue	Commercial-potable	3	1999, 2000
3	1502 Savannah Avenue	Commercial-potable	7	1997, 1999, 2000, 2001
4	822 Anclothe Road	Commercial-potable	6	1990, 1997, 2000, 2001
5	1599 Rainville Road	Commercial-potable	6	1990, 1997, 1999, 2000, 2001
6	1456 Savannah Avenue	Commercial-potable	2	2000
7	1553 Savannah Avenue	Commercial-potable	7	1988, 1990, 1997, 2000, 2001
8	1525 Rainville Road	Commercial-potable	2	2000
9	1232 N. Florida Avenue	Residential-potable	2	2000, 2001
10	1222 N. Florida Avenue	Residential-potable	5	2000, 2001
11	1218 N. Florida Avenue	Residential-potable	1	2000
12	1210 N. Florida Avenue	Residential-potable	4	2000, 2001
13	1234 N. Florida Avenue	Residential-potable	2	2000
14	905 Riverside Drive	Residential-potable	6	2000, 2001
15	3020 Buff Boulevard	Residential-potable	3	1999, 2000, 2001
16	1328 Calvary Road	Residential-potable	2	2000, 2001
17	1421 Calvary Road	Residential-potable	1	2000
18	1132 Hickory Lane	Residential-potable	3	2000, 2001
19	1916 Geronimo Drive	Residential-potable	2	2000, 2001
20	1681 Wilmar Drive	Residential-potable	1	1999
21	1124 Hickory Lane	Residential-potable	1	1990
22	252 Jeru Boulevard	Residential-potable	3	2000, 2001
23	204 Jeru Boulevard	Residential-potable	3	2000, 2001

Table 12. Private well sample locations and dates sampled (continued)

Map No.	Address	Well Type	Sampling Events (No.)	Year
24	1771 Meyers Cove Drive	Irrigation	1	2001
25	1749 Meyers Cove Drive	Irrigation	1	2001
26	1727 Meyers Cove Drive	Irrigation	1	2001
27	800 Anclote Road	Commercial-potable	2	1990, 1997
28	1140 Anclote Road	Irrigation	1	1990
29	701 Anclote Road	Irrigation	1	1990
30	1253 N. Florida Avenue	Irrigation	1	1997
31	1202 Hickory Lane	Residential-potable	1	1997
32	2105 Wallace Boulevard	Residential-potable	1	1997
33	507 Anclote Road	Community public	1	1997
34	764 Chesapeake Drive	Irrigation	1	1997
35	1389 Rainville Road	Residential-potable	1	1997
36	374 Jeru Boulevard	Irrigation	1	1997
37	1138 Hickory Lane	Residential-potable	1	1988
38	2113 Cemetery Road	Residential-potable	1	1988

Table 13. Private Well Summary Data—Contaminants Detected at Levels Above Comparison Values, Residential Wells

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppb)	Source	
Semivolatile Organic Compounds (SVOCs)								
bis(2-Ethylhexyl)phthalate	3.1	7.6	S	Mar-00	3/12	3	CREG	3
Inorganics-Metals								
Arsenic (As)	0.65	24	NW	Mar-00	36/37	0.02	CREG	36
Calcium (Ca)	18,000	100,000	NW	Feb-97	6/6	NA		NA
Chromium (Cr)	1	44	NW	Jun-00	32/37	30	child RMEG	1
Lead (Pb)	0.12	270	S	Mar-01	24/38	15	EPA AL	4
Magnesium (Mg)	4,700	21,000	NW	Feb-97	6/6	NA		NA
Nickel (Ni)	0.62	120	NW	Mar-00	18/36	100	LTHA	1
Potassium (K)	1,100	2,200	NW	Jan-88	2/2	NA		NA
Sodium (Na)	9,100	510,000	NW	Jun-00	40/40	NA		NA
Thallium (Tl)	0.097	1.6	S	Mar-01	4/36	0.5	LTHA	1
Inorganic-Other								
Chloride (Cl)	25,400	420,000	NW	Feb-97	4/4	250,000	NSDWR	1

Radiologic Parameters	Minimum (pCi/L)	Confidence	Maximum (pCi/L)	Confidence	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
								Value (pCi/L)	Source	
Gross Alpha	0.00	±0.40	26.20	±5.00	S	Mar-00	27/36	15	MCL	1
Gross Beta	0.90	±0.20	10.10	±1.00	E	Apr-99	5/5	NA		NA

Sources: Flow 2001; Pinellas County Health Department 1990, 2002; FDOH 1997.

Key:	CREG	cancer risk evaluation guide	NA	not available
	E	east of site	NSDWR	National Secondary Drinking Water Regulation (U.S. Environmental Protection Agency)
	EPA AL	U.S. Environmental Protection Agency action level	NW	northwest of site
	LTHA	lifetime health advisory (U.S. Environmental Protection Agency)	pCi/L	picocuries per liter
	MCL	maximum contaminant level (U.S. Environmental Protection Agency)	ppb	parts per billion
			RMEG	reference dose media evaluation guide
			S	south of Anclote River

Table 14. Private Well Summary Data—Contaminants Detected at Levels Above Comparison Values, Commercial Wells

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV		
						Value (ppb)	Source			
Semivolatile Organic Compounds (SVOCs)										
bis(2-Ethylhexyl)phthalate	2	4.4	E	Mar-00	3/6	6	CREG	1		
Inorganics-Metals										
Arsenic (As)	0.14	26	E	Mar-00	30/33	0.02	CREG	30		
Calcium (Ca)	58,000	357,000	E	Jul-90	10/10	NA		NA		
Iron (Fe)	20 I	18,000	E	Mar-00	28/35	11,000	RBC-N	1		
Magnesium (Mg)	5,300	48,000	E	Feb-97	9/9	NA		NA		
Nickel (Ni)	0.2	290	E	Mar-00	17/30	100	LTHA	1		
Potassium (K)	2,300	2,300	E	Jan-88	1/1	NA		NA		
Sodium (Na)	21,000	350,000	E	Feb-97	33/33	NA		NA		
Thallium (Tl)	0.19	3.1	E	Mar-00	4/30	0.5	LTHA	2		
Zinc (Zn)	50	3,700	E	Mar-01	23/33	2,000	LTHA	1		
Inorganics-Other										
Chloride (Cl)	50,000	760,000	E	Feb-97	9/9	250,000	NSDWR	2		
Sulfate (SO ₄)	7,600	650,000	E	Jul-90	9/9	250,000	NSDWR	2		
Radiologic Parameters	Minimum (pCi/L)	Confidence	Maximum (pCi/L)	Confidence	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
								Value (pCi/L)	Source	
Gross Alpha	0.00	±0.70	23.00	±6.00	E	Jan-88	19/22	15	MCL	1
Gross Beta	0.70	±0.20	13.00	±1.00	E	Apr-99	4/4	NA		NA
Radium-226	0.20	±0.10	8.60	±0.20	E ^a	Mar-00	21/21	5	MCL	1

Sources: Flow 2001; Pinellas County Health Department 1990, 2002; FDOH 1997.

Note: ^aAt this location, radium-226 plus radium-228 was 10.20±0.50 pCi/L.

Key:

CREG cancer risk evaluation guide

E east of site

I approximate value between the detection level and quantitation level

LTHA lifetime health advisory (U.S. EPA)

MCL maximum contaminant level (U.S. EPA)

NA not available

NSDWR National Secondary Drinking Water Regulation (U.S. EPA)

pCi/L picocuries per liter

ppb parts per billion

RBC-N risk-based concentration, for noncancer effects

Table 15. Private Well Summary Data—Contaminants Detected at Levels Above Comparison Values, Irrigation Wells

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (CV)		Number Above CV
						Value (ppb)	Source	
Inorganics-Metals								
Arsenic (As)	1.1	4.4	E	Feb-97	6/8	0.02	CREG	6
Calcium (Ca)	50,000	95,000	NW	Jul-90	5/5	NA		NA
Magnesium (Mg)	21,000	44,000	S	Feb-97	5/5	NA		NA
Sodium (Na)	34,000	280,000	S	Feb-97	8/8	NA		NA
Zinc (Zn)	24	2,820	E	Jul-90	6/8	2,000	LTHA	1
Inorganics-Other								
Chloride (Cl)	265,000	580,000	S	Feb-97	5/5	250,000	NSDWR	5

Sources: Flow 2001; Pinellas County Health Department 1990, 2002; FDOH 1997.

Key:

E east of site
 CREG cancer risk evaluation guide
 LTHA lifetime health advisory (U.S. Environmental Protection Agency)
 NA not available
 NSDWR National Secondary Drinking Water Regulation (U.S. Environmental Protection Agency)
 ppb parts per billion
 NW northwest of site
 S south of Anclote River

Table 16. Surface Water Summary Data, Ancote River, Upstream

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppb)	Comparison Value Source	Number Above CV
Inorganics-Metals								
Aluminum (Al)	40	600	upstream	Apr-89	3/50	37,000	RBC-N	0
Antimony (Sb)	9	850	upstream	Jan-89	5/50	4	child RMEG	5
Arsenic (As)	1.3 X	5.3 X	SW-2	Mar-93	9/50	0.02	CREG	9
Barium (Ba)	7 X	280	upstream	May-91	20/50	700	child RMEG	0
Boron (B)	990	5,800	upstream	Apr-89	38/38	600	LTHA	38
Calcium (Ca)	80,700	290,000	SW-06	Jan-88	12/12	NA		
Chromium (Cr)	6.5 X	46	upstream	Jan-87	3/50	30	child RMEG	0
Copper (Cu)	2.5 X	18.3 X	SW-3	Mar-93	10/12	1,300	MCLG	0
Iron (Fe)	10	1,800	upstream	Aug-01	41/49	11,000	RBC-N	0
Lead (Pb)	1.2 X	4	SW-1	Mar-93	4/12	15	EPA AL	0
Lithium (Li)	41	370	upstream	Apr-89	34/38	730	RBC-N	0
Magnesium (Mg)	184,000	1,110,000	SW-5	Mar-93	12/12	NA		
Manganese (Mn)	3	30	upstream	Oct-88	11/50	500	child RMEG	0
Mercury (Hg)	0.17 X	1	SW-4A	Mar-93	7/12	2	LTHA, Inorganic Hg	0
Nickel (Ni)	2	100	upstream	Jul-90	8/50	100	LTHA	0
Potassium (K)	73,200	398,000	SW-5	Mar-93	12/12	NA		
Selenium (Se)	7.2 X	23.2 X	SW-2	Mar-93	2/12	50	child RMEG, LTHA	0
Sodium (Na)	1,590,000	8,910,000	SW-3	Mar-93	12/12	NA		

Table 16. Surface Water Summary Data, Anclole River, Upstream (continued)

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppb)	Comparison Value Source	Number Above CV
Inorganics-Other								
Fluoride (F)	370	81,000	upstream	May-91	40/49	4,000	MCL	12
Phosphate-phosphorus	50	140	SW-2	Mar-93	5/10	NA		
Ortho-P (O-P)	10	610	upstream	Oct-88	17/38	NA		
Sulfate (SO ₄)	500,000	5,200,000	upstream	Jan-89	38/38	250,000	NSDWRs	38
Radiologic Parameters (pCi/L)								
Gross Alpha	-100±200	199±122	upstream	Jul-94	22/40	15	MCL	15
Gross Beta	3.5±0.3	583±114	upstream	Jul-94	38/40	4	MCL	38
Radium-226	0.00±0.4	5.4±0.5	upstream	Jul-97	34/38	5	MCL	33
Radon-222	-80±40	120±70	upstream	Jan-89	21/38	300	MCL	0
Polonium-210	0.1±0.9	14.1±3	upstream	Jun-93	14/37	NA		

Sources: NUS 1989; SMC 1987-present; Weston 1993.

Key:

CREG	cancer risk evaluation guide
EPA AL	U.S. Environmental Protection Agency action level
LTHA	lifetime health advisory (U.S. Environmental Protection Agency)
MCL	maximum contaminant level (U.S. Environmental Protection Agency)
MCLG	maximum contaminant level goal (U.S. Environmental Protection Agency)
NA	not available
NSDWRs	National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency)
pCi/L	picocuries per liter
ppb	parts per billion
RBC-N	risk-based concentration, for noncancer effects (U.S. Environmental Protection Agency)
RMEG	reference dose media evaluation guide
SMC	Stauffer Management Company
X	result in less than the contract-required detection limit, but greater than or equal to the instrument detection limit

Table 16. Surface Water Summary Data, Anclote River, Upstream (continued)

Notes:

- Upstream sample was taken as part of the ongoing SMC Groundwater Monitoring Program. SMC's upstream samples are collected immediately upstream of the Stauffer site in the Anclote River directly in line with the eastern property boundary.
- Duplicate samples, collected primarily by SMC as part of its groundwater monitoring program, are counted as individual samples in these summary statistics.
- Negative radiologic readings represent samples in which the amount of radioactivity in the sample blank was larger than that in the sample.

Table 17. Surface Water Summary Data, Anclothe River, Adjacent

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppb)	Comparison Value Source	Number Above CV
Inorganics-Metals								
Aluminum (Al)	39.7 X	29,000	SW-05	Jan-88	6/6	37,000	RBC-N	0
Arsenic (As)	1.1 X	48 J,N	SW-05	Jan-88	5/6	0.02	CREG	5
Barium (Ba)	8 X	84	SW-05	Jan-88	5/6	700	child RMEG	0
Calcium (Ca)	290	280,000	SW-05	Jan-88	6/6	NA		
Chromium (Cr)	80	80	SW-05	Jan-88	1/6	30	child RMEG	1
Copper (Cu)	2.8 X	10.7 X	SW-6C	Mar-93	3/6	1,300	MCLG	0
Iron (Fe)	60.6 X	28,000	SW-05	Jan-88	5/6	11,000	RBC-N	1
Lead (Pb)	1.2 X	150	SW-05	Jan-88	4/6	15	EPA AL	1
Magnesium (Mg)	160,000	996,000	SW-6B	Mar-93	6/6	NA		
Manganese (Mn)	180	180	SW-05	Jan-88	1/6	500	child RMEG	0
Mercury (Hg)	0.22 X	0.22 X	SW-6A	Mar-93	1/6	2	LTHA	0
Nickel (Ni)	89	89	SW-05	Jan-88	1/6	100	LTHA	0
Potassium (K)	68,000	335,000	SW-6B	Mar-93	6/6	NA		
Sodium (Na)	1,200,000	8,540,000	SW-6C	Mar-93	6/6	NA		
Vanadium (V)	370	370	SW-05	Jan-88	1/6	260	RBC-N	1
Zinc (Zn)	470 J	470 J	SW-05	Jan-88	1/6	2,000	LTHA	0
Inorganics-Other								
Fluoride (F)	510	17,000 J	SW-07	Jan-88	6/6	4,000	MCL	2
Phosphate-phosphorus	50	50	SW-6C	Mar-93	1/4	NA		
Total Phosphorus	40,000 J	40,000 J	SW-05	Jan-88	½	NA		

Table 17. Surface Water Summary Data, Anclote River, Adjacent (continued)

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppb)	Comparison Value Source	Number Above CV
Radiologic parameters (pCi/L)								
Gross Alpha	1±1	30±30	SW-05	Jan-88	2/2	15	MCL	2
Gross Beta	15±2	110±30	SW-05	Jan-88	2/2	4	MCL	2

Sources: Sources: NUS 1989; SMC 1987-present, Weston 1993.

Key:

CREG cancer risk evaluation guide
 EPA AL U.S. Environmental Protection Agency action level
 J estimated quantity below the quantitation limit
 LTHA lifetime health advisory (U.S. Environmental Protection Agency)
 MCL maximum contaminant level (U.S. Environmental Protection Agency)
 MCLG maximum contaminant level goal (U.S. Environmental Protection Agency)
 N presumptive evidence of presence of material
 NA not available
 pCi/L picocuries per liter
 ppb parts per billion
 RBC-N risk-based concentration, for noncancer effects (EPA)
 RMEG reference dose media evaluation guide
 X result in less than the contract-required detection limit, but greater than or equal to the instrument detection limit

Note: Duplicate samples are counted as individual samples in these summary statistics.

Table 18. Surface Water Summary Data, Ancote River, Meyers Cove

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppb)	Comparison Value Source	Number Above CV
Inorganics-Metals								
Aluminum (Al)	50	500	downstream	Jul-88	38/60	37,000	RBC-N	0
Antimony (Sb)	8	860	downstream	Jan-89	8/60	4	child RMEG	8
Arsenic (As)	1 X	6 X	SW-7B	Mar-93	12/60	0.02	CREG	12
Barium (Ba)	7 X	200	downstream	Jul-92	14/60	700	child RMEG	0
Boron (B)	970	4,500	downstream	Aug-01	55/55	600	LTHA	55
Calcium (Ca)	228,000	318,000	SW-7C	Mar-93	5/5	NA		
Chromium (Cr)	20	20	downstream	Jan-89	1/59	30	child RMEG	0
Copper (Cu)	2.1 X	10.4 X	SW-7A	Mar-93	4/5	1,300	MCLG	0
Iron (Fe)	20	14,000	downstream	Apr-89	49/60	11,000	RBC-N	1
Lead (Pb)	1.4 X	1.5 X	SW-7B	Mar-93	2/5	15	EPA AL	0
Lithium (Li)	36	370	downstream	Jan-92	51/55	730	RBC-N	0
Magnesium (Mg)	830,000	1,300,000	SW-7C	Mar-93	5/5	NA		
Manganese (Mn)	2	100	downstream	Jul-90	26/60	500	child RMEG	0
Mercury (Hg)	0.15 X	0.36	SW-7A	Mar-93	3/5	2	LTHA, Inorganic	0
Nickel (Ni)	1	100	downstream	Jul-90	12/60	100	LTHA	0
Potassium (K)	240,000	588,000	SW-7C	Mar-93	5/5	NA		
Sodium (Na)	6,700,000	10,900,000	SW-7C	Mar-93	5/5	NA		
Inorganics-Other								
Fluoride (F)	420	80,000	downstream	May-91	48/60	4,000	MCL	27

Table 18. Surface Water Summary Data, Anclote River, Meyers Cove (continued)

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppb)	Comparison Value Source	Number Above CV
Phosphate-phosphorus	60	240	SW-7B	Mar-93	3/4	NA		
Ortho-P (O-P)	10	1,300	downstream	Jan-95	31/55	NA		
Sulfate (SO ₄)	200,000	2,980,000	downstream	Aug-00	55/55	250,000	NSDWRs	53
Radiologic parameters (pCi/L)								
Gross Alpha	-120±90	400±200	downstream	May-87	32/55	15	MCL	11
Gross Beta	3.6±0.3	500±200	downstream	Jan-87	51/57	4	MCL	56
Radium-226	-0.03±0.08	26±0.7	downstream	Apr-90	53/56	5	MCL	1
Radon-222	-80±40	240±0	downstream	Jan-92	33/53	300	MCL	0
Polonium-210	-3±2	62±13	downstream	Jan-88	14/54	NA		

Sources: NUS 1989; SMC 1987-present; Weston 1993.

Key:

CREG	cancer risk evaluation guide
EPA AL	U.S. Environmental Protection Agency action level
LTHA	lifetime health advisory (U.S. Environmental Protection Agency)
MCL	maximum contaminant level (U.S. Environmental Protection Agency)
MCLG	maximum contaminant level goal (U.S. Environmental Protection Agency)
NA	not available
NSDWRs	National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency)
ppb	parts per billion
pCi/L	picocuries per liter
RBC-N	risk-based concentration, for noncancer effects (U.S. Environmental Protection Agency)
RMEG	reference dose media evaluation guide
X	result in less than the contract-required detection limit, but greater than or equal to the instrument detection limit

Notes:

- Downstream samples were taken as part of the SMC ongoing groundwater sampling program. Each semiannual sampling event takes one sample upstream and one downstream in Meyers Cove. Downstream samples are generally taken downstream of the calcium fluoride sludge ponds, 75 to 150 feet off the north shoreline. This sampling site fits into Meyers Cove designation.
- Negative radiologic readings represent samples in which the amount of radioactivity in the sample blank was larger than that in the sample.
- Duplicate samples, collected primarily by SMC as part of its groundwater monitoring program, are counted as individual samples in these summary statistics.

Table 19. Surface Water Summary Data, Anclote River, Downstream

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppb)	Comparison Value Source	Number Above CV
Inorganics-Metals								
Aluminum (Al)	22.9 X	640	SW-08	Jan-88	9/9	37,000	RBC-N	0
Arsenic (As)	500 J,N	500 J,N	SW-10	Jan-88	1/9	0.02	CREG	1
Barium (Ba)	6.2 X	7 X	SW-9	Mar-93	7/9	700	child RMEG	0
Calcium (Ca)	237,000	310,000	SW-10	Jan-88	9/9	NA		
Copper (Cu)	9.7 X	12 X	SW-10	Mar-93	4/9	1,300	MCLG	0
Iron (Fe)	17 X	290	SW-08	Jan-88	9/9	11,000	RBC-N	0
Lead (Pb)	1.1 X	2.8 X	SW-9	Mar-93	4/9	15	EPA AL	0
Magnesium (Mg)	810,000	1,210,000	SW-9	Mar-93	9/9	NA		
Mercury (Hg)	0.13 X	0.25 X	SW-11	Mar-93	5/9	2	LTHA, Inorganic	0
Potassium (K)	24,000	442,000	SW-12	Mar-93	9/9	NA		
Selenium (Se)	1.8 X	1.8 X	SW-9	Mar-93	1/9	50	child RMEG	0
Sodium (Na)	6,400,000	9,950,000	SW-10	Mar-93	9/9	NA		
Thallium (Tl)	16.8 X	300 J,N	SW-10	Jan-88	2/9	0.5	LTHA	2
Vanadium (V)	40	40	SW-10	Jan-88	1/9	260	RBC-N	0
Zinc (Zn)	10.1 X	30 J	SW-10	Jan-88	2/9	2,000	LTHA	0
Inorganics-Other								
Fluoride (F)	500	3,000 J	SW-10	Jan-88	8/9	4,000	MCL	0
Phosphate-phosphorus	60	60	SW-11	Mar-93	1/7	NA		
Total Phosphorus	210 J	210 J	SW-08	Jan-88	½	NA		

Table 19. Surface Water Summary Data, Anclote River, Downstream (continued)

Chemical	Minimum Detected (ppb)	Maximum Detected (ppb)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppb)	Comparison Value Source	Number Above CV
Radiologic Parameters (pCi/L)								
Gross Alpha	-30±60	50±100	SW-08	Jan-88	2/2	15	MCL	1
Gross Beta	190±96	280±60	SW-10	Jan-88	2/2	4	MCL	2

Sources: NUS 1989; SMC 1987-present; Weston 1993.

Key:

CREG cancer risk evaluation guide
 EPA AL U.S. Environmental Protection Agency action level
 J estimated quantity below the quantitation limit
 LTHA lifetime health advisory (U.S. Environmental Protection Agency)
 MCL maximum contaminant level (U.S. Environmental Protection Agency)
 MCLG maximum contaminant level goal (U.S. Environmental Protection Agency)
 N presumptive evidence of presence of material
 NA not available
 ppb parts per billion
 pCi/L picocuries per liter
 RBC-N risk-based concentration, for noncancer effects
 RMEG reference dose media evaluation guide
 X result in less than the contract-required detection limit, but greater than or equal to the instrument detection limit

Notes:

- Negative radiologic readings represent samples in which the amount of radioactivity in the sample blank was larger than that in the sample.
- Duplicate samples are counted as individual samples in these summary statistics.

Table 20. Sediment Summary Data, Ancote River, Upstream

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppm)	Comparison Value Source	Number Above CV
Inorganics-Metals								
Aluminum (Al)	120	2,160	SED1	Apr-91	12/12	100,000	child i-EMEG	0
Arsenic (As)	0.4	1.6	SED5	Apr-91	5/7	0.5	CREG	4
Barium (Ba)	1.3	6.5	SED1	Apr-91	5/7	4,000	child RMEG	0
Calcium (Ca)	1,200	13,300	SED3	Apr-91	8/12	NA		
Chromium (Cr)	1.3	7.1	SED1	Apr-91	11/12	200	child RMEG	0
Cobalt (Co)	1	1	SED5	Apr-91	1/7	500	child i-EMEG	0
Copper (Cu)	8.2	32.6	SED1	Apr-91	6/12	3,100	RBC-N	0
Iron (Fe)	180	2,020	SED1	Apr-91	12/12	23,000	RBC-N	0
Lead (Pb)	1.4 J	19.9	SED1	Apr-91	8/12	400	EPA AL	0
Magnesium (Mg)	500	1,700	SED5	Apr-91	11/12	NA		
Manganese (Mn)	1.9	19.8	SED3	Apr-91	6/12	3,000	child RMEG	0
Nickel (Ni)	2.5	3	SED5	Apr-91	2/7	1,000	child RMEG	0
Potassium (K)	280	850	SED3	Apr-91	6/12	NA		
Selenium (Se)	0.34	0.34	SED1	Apr-91	1/7	300	child c-EMEG	0
Sodium (Na)	3,400	8,940	SED3	Apr-91	10/11	NA		
Vanadium (V)	1.6	8.2	SED1	Apr-91	6/7	200	child i-EMEG	0
Zinc (Zn)	5.5	33.3	SED1	Apr-91	5/12	20,000	child c-EMEG	0
Inorganics-Other								
Fluoride (F)	2.98	18,000 J	SD-09	Jan-88	17/18	3,000	child c-EMEG	1
Phosphate-phosphorus	19.4	439	SD-4C	Mar-93	11/11	NA		

Table 20. Sediment Summary Data, Ancote River, Upstream (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppm)	Comparison Value Source	Number Above CV
Total Phosphorus	72 J	435	SED1	Apr-91	6/6	NA		
TOC	924	34,800	SD-4C	Mar-93	11/11	NA		
Radiologic parameters (pCi/g)								
Gross Alpha	0.3±0.1	0.6±0.2	SD-09	Jan-88	2/2	NA		
Gross Beta	0.1±0.1	0.3±0.2	SD-09	Jan-88	2/2	NA		

Sources: NUS 1989, 1991; Weston 1991, 1993.

Key:

CREG	cancer risk evaluation guide
EPA AL	U.S. Environmental Protection Agency action level
c-EMEG	chronic environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
i-EMEG	Intermediate environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
J	estimated quantity below the quantitation limit
NA	not available
ppm	parts per million
pCi/g	picocuries per gram
RBC-N	risk-based concentration, for noncancer effects (EPA)
RMEG	reference dose media evaluation guide
TOC	total organic carbon

Note: Duplicate samples are counted as individual samples in these summary statistics.

Table 21. Sediment Summary Data, Ancote River, Adjacent

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppm)	Comparison Value Source	Number Above CV
Inorganics-Metals								
Aluminum (Al)	358	3,300	SED8	Apr-91	17/17	100,000	child i-EMEG	0
Arsenic (As)	0.49	3.4	SED8	Apr-91	11/14	0.5	CREG	10
Barium (Ba)	0.88	6.4	SED8	Apr-91	12/14	4,000	child RMEG	0
Cadmium (Cd)	1.4	1.4	SD-15C	Mar-93	1/14	10	child c-EMEG	0
Calcium (Ca)	1,650	23,200	SED8	Apr-91	17/17	NA		
Chromium (Cr)	1.7	11.6	SED8	Apr-91	17/17	200	child RMEG	0
Cobalt (Co)	1.2	1.2	SED9	Apr-91	1/14	500	child i-EMEG	0
Copper (Cu)	3.2	33.7	SED8	Apr-91	15/17	3,100	RBC-N	0
Iron (Fe)	370	3,850	SED8	Apr-91	17/17	23,000	RBC-N	0
Lead (Pb)	1.4J	8.4J	SD-07	Jan-88	16/17	400	AL	0
Magnesium (Mg)	357	3,330	SED8	Apr-91	17/17	NA		
Manganese (Mn)	1.4	17.9	SED9	Apr-91	16/17	3,000	child RMEG	0
Mercury (Hg)	0.098	0.098	SD-16B	Mar-93	1/14	20	child RMEG,	0
Nickel (Ni)	1.5	4.6	SED8	Apr-91	3/14	1,000	child RMEG	0
Potassium (K)	204	1,630	SED8	Apr-91	12/17	NA		
Selenium (Se)	0.54	0.54	SED8	Apr-91	1/14	300	child c-EMEG	0
Sodium (Na)	1,740	14,900	SED8	Apr-91	16/17	NA		
Vanadium (V)	1.8	12.8	SED8	Apr-91	14/14	200	child i-EMEG	0
Zinc (Zn)	3.8	36.7	SED8	Apr-91	12/17	20,000	child c-EMEG	0

Table 21. Sediment Summary Data, Anclote River, Adjacent (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppm)	Comparison Value Source	Number Above CV
Inorganics-Other								
Fluoride (F)	3.45	9,100J	SD-07	Jan-88	18/18	3,000	child c-EMEG	1
Phosphate-phosphorus	37.2	1,000	SD-15C	Mar-93	11/11	NA		
Total Phosphorus	217	1,700J	SD-07	Jan-88	7/7	NA		
TOC	4,610	14,100	SD-6A	Mar-93	4/4	NA		
Radiological parameters (pCi/g)								
Gross Alpha	0.7±0.3	13.5±1	SD-15B	Mar-93	9/9	NA		
Gross Beta	0.2±0.2	29.8±0.4	SD-16B	Mar-93	9/9	NA		
Radium-226	0.25*	0.79*	SD-15A	Mar-93	6/7	0.15	NCRP	6
Radon-222	0.2*	0.72*	SD-15A	Mar-93	6/7	NA		
Polonium-210	0.49*	2*	SD-15A	Mar-93	6/7	5.7	NCRP	0

Sources: NUS Corp 1989, NUS Corp 1991, Weston 1991, Weston 1993.

Key: ppm parts per million
pCi/g picoCuries per gram
CREG Cancer Risk Evaluation Guide
EPA AL EPA Action Level
c-EMEG chronic Environmental Media Evaluation Guide (ATSDR)
i-EMEG Intermediate Environmental Media Evaluation Guide (ATSDR)
J estimated quantity below the quantitation limit
NA Not available
NCRP National Council on Radiation Protection and Measurements
RBC-N Risk-Based Concentration, for non-cancer effects (EPA)
RMEG Reference Dose Media Evaluation Guide
* Uncertainty/confidence terms not available

Table 22. Sediment Summary Data, Anclote River, Meyers Cove

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppm)	Comparison Value Source	Number Above CV
Inorganics-Metals								
Aluminum (Al)	2,130	9,500	SD-04	Jan-88	9/9	100,000	child i-EMEG	0
Arsenic (As)	1.7	8.5 J,N	SD-04	Jan-88	8/8	0.5	CREG	8
Barium (Ba)	3.4	16	SD-04	Jan-88	8/8	4,000	child RMEG	0
Beryllium (Be)	0.26	0.29	SD-14C	Mar-93	4/8	50	child c-EMEG	0
Cadmium (Cd)	0.95	0.95	SD-14C	Mar-93	1/8	10	child c-EMEG	0
Calcium (Ca)	11,600	60,000 J	SD-04	Jan-88	9/9	NA		
Chromium (Cr)	7.1	30	SD-04	Jan-88	9/9	200	child RMEG	0
Copper (Cu)	6.4	25	SC-SD-09	Apr-89	8/9	3,100	RBC-N	0
Iron (Fe)	2,280	8,500	SD-04	Jan-88	9/9	23,000	RBC-N	0
Lead (Pb)	5.6	17.1	SD-13A	Mar-93	9/9	400	EPA AL	0
Magnesium (Mg)	1,180	6,300	SD-04	Jan-88	9/9	NA		
Manganese (Mn)	8.1	36	SD-04	Jan-88	9/9	3,000	child RMEG	0
Mercury (Hg)	0.18	0.18	SD-13A	Mar-93	2/8	20	child RMEG	0
Nickel (Ni)	5.9	14	SD-04	Jan-88	3/8	1,000	child RMEG	0
Potassium (K)	309	2,100	SD-04	Jan-88	9/9	NA		
Selenium (Se)	0.26	1.2 J,N	SD-04	Jan-88	4/8	300	child c-EMEG	0
Silver (Ag)	2.4 J	2.4 J	SD-04	Jan-88	1/8	300	child RMEG	0
Sodium (Na)	3,600	21,000 J	SD-04	Jan-88	9/9	NA		
Vanadium (V)	6.9	32	SD-04	Jan-88	8/8	200	child i-EMEG	0
Zinc (Zn)	12.2	62 J	SD-04	Jan-88	9/9	20,000	child c-EMEG	0

Table 22. Sediment Summary Data, Anclote River, Meyers Cove (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppm)	Comparison Value Source	Number Above CV
Inorganics-Other								
Fluoride (F)	9.11	6,900 J	SD-04	Jan-88	12/12	3,000	child c-EMEG	1
Phosphate-phosphorus	51.9	3,750	SD-13A	Mar-93	11/11	NA		
Total Phosphorus	4,600 J	4,600 J	SD-04	Jan-88	1/1	NA		
TOC	14,200	120,000	SD-7A	Mar-93	4/4	NA		
Radiologic Parameters (pCi/g)								
Gross Alpha	14±3	30.2	SD-13A	Mar-93	7/8	NA		
Gross Beta	8±1	55.5	SD-13A	Mar-93	8/8	NA		
Radium-226	1.1*	2.4*	SD-13A	Mar-93	7/7	0.15	NCRP residential	7
Radon-222	0.99*	2.2*	SD-13A	Mar-93	7/7	NA		
Polonium-210	2.3*	7.7*	SD-13A	Mar-93	7/7	5.7	NCRP residential	1

Sources: NUS 1989, 1991, Weston 1991, 1993.

Key: CREG cancer risk evaluation guide
EPA AL U.S. Environmental Protection Agency action level
c-EMEG chronic environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
i-EMEG Intermediate environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
J estimated quantity below the quantitation limit
N presumptive evidence of presence of material
NA not available
NCRP National Council on Radiation Protection and Measurements
ppm parts per million
pCi/g picocuries per gram
RBC-N risk-based concentration, for noncancer effects (EPA)
RMEG reference dose media evaluation guide
TOC total organic carbon
* Uncertainty/confidence terms were not available.

Table 23. Sediment Summary Data, Anclote River, Downstream

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppm)	Comparison Value Source	Number Above CV
Volatile Organic Compounds								
Methylethyl ketone	99,000 J	99,000 J	SD-08	Jan-88	1/1	30,000	child RMEG	1
Toluene	160,000	160,000	SD-08	Jan-88	1/1	1,000	child i-EMEG	1
Inorganics-Metals								
Aluminum (Al)	190	2,190	SED11	Apr-91	11/11	100,000	child i-EMEG	0
Arsenic (As)	0.42	1.9	SED11	Apr-91	4/6	0.5	CREG	3
Barium (Ba)	1.1	3.9	SED11	Apr-91	4/6	4,000	child RMEG	0
Calcium (Ca)	940	10,200	SED11	Apr-91	8/11	NA		
Chromium (Cr)	1.3	9.7	SED11	Apr-91	6/11	200	child RMEG	0
Cobalt (Co)	1.8	1.8	SED11	Apr-91	1/6	500	child i-EMEG	0
Copper (Cu)	5.8	21.8	SED11	Apr-91	4/11	3,100	RBC-N	0
Iron (Fe)	100	2,420	SED11	Apr-91	11/11	23,000	RBC-N	0
Lead (Pb)	2.2	16 J	SD-08	Jan-88	6/11	400	EPA AL	0
Magnesium (Mg)	660	2,190	SED11	Apr-91	8/11	NA		
Manganese (Mn)	2	7.6	SED11	Apr-91	5/11	3,000	child RMEG	0
Nickel (Ni)	0.9	2.7	SED11	Apr-91	3/6	1,000	child RMEG	0
Potassium (K)	351	785	SED11	Apr-91	5/11	NA		
Selenium (Se)	0.44	0.44	SED11	Apr-91	1/6	300	child c-EMEG	0
Sodium (Na)	2,200	10,200	SED11	Apr-91	9/11	NA		
Thallium (Tl)	7,800	7,800	SC-SD-14	Apr-89	1/11	4	child RMEG	1
Vanadium (V)	2.1	10	SED11	Apr-91	6/6	200	child i-EMEG	0
Zinc (Zn)	4.7	22.5	SED11	Apr-91	4/11	20,000	child c-EMEG	0

Table 23. Sediment Summary Data, Anclote River, Downstream (continued)

Chemical	Minimum Detected (ppm)	Maximum Detected (ppm)	Location of Maximum	Date of Maximum	Frequency of Detection	Comparison Value (ppm)	Comparison Value Source	Number Above CV
Inorganics-Other								
Fluoride (F)	2.77	360 J	SD-08	Jan-88	12/13	3,000	child c-EMEG	0
Phosphate-phosphorus	38.8	211	SD-11	Mar-93	7/7	NA		
Total Phosphorus	31 J	620	SED10	Apr-91	6/6	NA		
TOC	1,160	17,900	SD-11	Mar-93	7/7	NA		
Radiologic Parameters (pCi/g)								
Gross Alpha	0.2±0.1	10±1	SD-10	Jan-88	2/2	NA		
Gross Beta	0.1±0.1	4±0.4	SD-10	Jan-88	2/2	NA		

Sources: NUS 1989, 1991; Weston 1991, 1993.

Key:

CREG cancer risk evaluation guide
 EPA AL U.S. Environmental Protection Agency action level
 c-EMEG chronic environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
 i-EMEG Intermediate environmental media evaluation guide (Agency for Toxic Substances and Disease Registry)
 J estimated quantity below the quantitation limit
 NA not available
 ppm parts per million
 pCi/g picocuries per gram
 RBC-N risk-based concentration, for noncancer effects (EPA)
 RMEG reference dose media evaluation guide
 TOC total organic carbon

Table 24. Surface Water Sampling Location Designations

Study	Date	Location Designation	Sample ID/Location ^a
Expanded site investigation (NUS 1989)	January 1988	Upstream	SW-06 SW-09
		Adjacent	SW-05 SW-07
		Meyers Cove	SW-04
		Downstream	SW-08 SW-10
Remedial investigation (Weston 1993)	March 1993	Upstream	SW-1 SW-2 SW-3 SW-4A SW-4B SW-4C SW-5
		Adjacent	SW-6A SW-6B SW-6C
		Meyers Cove	SW-7A SW-7B SW-7C
		Downstream	SW-8 SW-9 SW-10 SW-11 SW-12
Stauffer Management Company ongoing groundwater monitoring program	1987–present	Upstream	Upstream
		Adjacent	None
		Meyers Cove	Downstream
		Downstream	None

Notes:

^aSample IDs were changed slightly in some cases to distinguish samples from different studies taken from different locations, but given the same identifier in the original studies.

Table 25. Sediment Sampling Location Designations

Study	Date	ERG Designation	Sample ID/Location*
Expanded site investigation (NUS 1989)	January 1988	Upstream	SD-06 SD-09
		Adjacent	SD-05 SD-07
		Meyers Cove	SD-04
		Downstream	SD-08 SD-10
Sediment sampling program (Weston 1991)	April 1991	Upstream	SED 1 SED 2 SED 3 SED 4 SED 5
		Adjacent	SED 6 SED 7 SED 8 SED 9
		Meyers Cove	NONE
		Downstream	SED 10 SED 11 SED 12 SED 13
Listing site inspection (NUS 1991)	April 1989	Upstream	SC-SD-01 SC-SD-02 SC-SD-03 SC-SD-04 SC-SD-05
		Adjacent	SC-SD-06 SC-SD-07 SC-SD-08
		Meyers Cove	SC-SD-09
		Downstream	SC-SD-10 SC-SD-11 SC-SD-12 SC-SD-13 SC-SD-14

Table 25. Sediment Sampling Location Designations (continued)

Study	Date	ERG Designation	Sample ID/Location ^a
Remedial investigation (Weston 1993)	March 1993	Upstream	SD-1 SD-2 SD-3 SD-4A SD-4B SD-4C SD-5
		Adjacent	SD-6A SD-6B SD-6C SD-15A SD-15B SD-15C SD-16A SD-16B SD-16C
		Meyers Cove	SD-7A SD-7B SD-7C SD-13A SD-13B SD-13C SD-14A SD-14B SD-14C
		Downstream	SD-8 SD-9 SD-10 SD-11 SD-12

Notes:

^aSample IDs were changed slightly in some cases to distinguish samples from different studies taken from different location, but given the same identifier in the original studies.

Table 26. Meteorologic Data for the Stauffer Chemical Company Site

Parameter	Location of Meteorologic Station		
	PCDEM's Anclote Road Station	St. Petersburg/Clearwater Airport	Tampa International Airport
Source of data	PCDEM 2002	NCDC 2002	NCDC 2002
Period of record	1979–1996	1973–2002	1948–2002
Summary for the Common Period of Record (1979–1996)			
Total possible hours	157,800	157,800	157,800
Calm hours	8,276	9,108	12,184
Missing hours	17,213	4,265	408
Completeness	89.1%	97.3%	99.7%
Summary for the Period of Interest (January 1978–May 1981, School Hours Only)			
Total possible hours	7,056	9,976	9,976
Calm hours	96	164	134
Missing hours	719	458	0
Completeness	89.8%	95.4%	100.0%

Key:

PCDEM Pinellas County Department of Environmental Management

Note:

- A “missing hour” was defined as an hour that did not have a valid observation of wind speed or wind direction.
- For the period of interest, the PCDEM has a lower number of “total possible hours” because the station did not start operating until January 1979.

Table 27. Contaminant Emission Rates for Air Dispersion Model Inputs

Contaminant	Source	Emission Rate		Comments
		Grams/Second	Tons/Year	
Sulfur dioxide	Rotary kiln	41.4	1,436	Rate based on results from five stack tests, whose range of emission rates was 34.7 to 47.8 grams per second. The state of Florida used an emission rate of 41.2 grams per second in the dispersion modeling analysis done when preparing the state implementation plan for the nonattainment area.
	Boilers	1.28	44	Rate based on data reported in annual disclosure statements of boiler emissions. The data assumed that all sulfur present in the fuel converts to sulfur dioxide, which is essentially the same approach the U.S. Environmental Protection Agency EPA outlines in AP-42 (EPA 1995b) for sulfur dioxide emissions from boilers. This emission rate reflects SCC's emissions after 1975, when the facility changed to low-sulfur fuels.
Particulate matter (size fraction not specified)	Rotary kiln	5.33	185	SCC has questioned whether these emissions data were accurate. SCC believed that sulfur dioxide gases collected by the sampling impingers converted to sulfate and were measured as particulate, rather than gaseous, emissions. In short, SCC suspected these emissions data include a positive measurement bias.
	Boilers	0.42	14.6	Rate based on data from a single stack test.
	Nodule cooler	0.28	9.6	Rate is an average of six stack tests.
	Coke dryer	0.45	15.6	Rate based on data SCC reported in its 1977 annual emissions disclosure statement.
	Furnace	0.23	8.1	Rate is an average of two of SCC's 1973 and 1974 emissions disclosure statements.
	Condenser	0.18	6.4	Rate is an average of two of SCC's 1973 and 1974 emissions disclosure statements.
	Materials handling	0.08	2.8	Rate is based on data SCC reported in its 1977 annual emissions disclosure statement.

Table 27. Contaminant Emission Rates for Air Dispersion Model Inputs (continued)

Contaminant	Source	Emission Rate		Comments
		Grams/ Second	Tons/ Year	
Fluorides	Rotary kiln	0.165	5.7	Rate based on SCC's 1973 and 1974 emissions disclosure statements.
	Nodule cooler	0.0072	0.25	Average of six stack test results.
	Condenser	0.0012	0.041	Rate based on SCC's 1973 and 1974 emissions disclosure statements.
	Furnace	0.0016	0.054	Rate based on SCC's 1973 and 1974 emissions disclosure statements, which account for emissions through the tap hole scrubber and not fugitive emissions that occur during furnace tapping.

Key: SCC Stauffer Chemical Company

Table 28. Stack Parameters for Air Dispersion Modeling Analysis

Source	Stack Height (feet)	Stack Diameter (feet)	Exit Temperature (°F)	Flow Rate or Velocity
Boilers	20	2	417	5,430 ACFM
Rotary kiln (before May 1979)	85	22	134	0.2 m/s
Rotary kiln (after May 1979)	160	4	134	4.2 m ³ /s
Nodule cooler scrubber	85	4	123	56,400 ACFM
Coke dryer	50	2.5	122	12,600 ACFM
Materials handling "burden bin"	100	1.8	97	8,120 ACFM
Phosphorus condenser	112	1	80	1,500 ACFM
Furnace tap hole scrubber	21	3	120	20,800 ACFM

Key:

ACFM actual cubic feet per minute
m/s meters per second
m³/s cubic meters per second

Table 29. Descriptions and Coordinates for Locations Included in the Air Dispersion Modeling Analysis

Location Number*	Description	Coordinates	
		Latitude	Longitude
1	North-northwest of SCC, in Pasco County	28.175558	-82.780278
2	Gulfside Elementary School	28.173058	-82.774167
3	Residential neighborhood in southern Pasco County, northeast of SCC	28.173058	-82.763889
4	Residential neighborhood west of SCC	28.168336	-82.781111
5	Industrial complex east of SCC	28.166669	-82.771944
6	Piney Point, on shore of Gulf of Mexico	28.161947	-82.797500
7	Residential neighborhood southwest of SCC, and in prevailing downwind direction	28.163891	-82.783056
8	Area near Anclote Road monitoring station and Flaherty Marina	28.163058	-82.773889
9	Residential neighborhood south of SCC	26.160280	-82.778056
10	Residential neighborhood south-southwest and further downwind of SCC	28.155836	-82.784167
11	Howard Park, on shore of Gulf of Mexico	28.153891	-82.793333
12	Residential neighborhood southeast of SCC	28.158613	-82.771944

Key:

SCC Stauffer Chemical Company

*See Figure 19 for a map of these 12 locations.

Table 30. Predicted and Observed Sulfur Dioxide Concentrations: Anclole Road Monitoring Station

Averaging Time	Before or After Stack Reconfiguration	Sulfur Dioxide Concentration (parts per billion)	
		Predicted	Observed
Annual average	Before	9.2	14.3
Highest 24-hour average	Before	170	311
Highest 1-hour average	Before	1,144	840
Annual average	After	1.6	4.9
Highest 24-hour average	After	45	77
Highest 1-hour average	After	415	290

Notes:

- The Stauffer Chemical Company (SCC) reconfigured the rotary kiln stack in May 1979. The emission rate for this source was not changed, but the increase in stack height and decrease in stack diameter facilitated the atmospheric dispersion in the emissions, thus resulting in a notable decrease in sulfur dioxide levels at the Anclole Road monitoring station after May 1979.
- The predicted concentration estimates the incremental effect that SCC's air emissions have on actual ambient air concentrations. The observed concentration reflects the contributions from all sulfur dioxide emissions sources in the Tarpon Springs area.
- For the predicted concentrations, the "annual average" value is the average concentration observed over 5 years of meteorologic conditions; the "highest 24-hour average" and "highest 1-hour average" concentrations are the peak levels observed over this same time frame.
- The observed concentrations for the time before the stack reconfiguration are computed from all measurements made between July 1977 and May 1979; the observed concentrations for the time after the stack reconfiguration are computed from all measurements made between June 1979 and November 1981, when SCC reportedly shut down its furnace permanently. The "annual average" concentration shown is the average of all observations collected during the two time frames. The average sulfur dioxide concentration at the Anclole Road monitoring station after SCC shut down was 1.42 ppb.

Table 31. Predicted Percent Decrease in Sulfur Dioxide Concentrations after the 1979 Rotary Kiln Stack Modification

Location Number (see Table 29)	Percent Decrease in Predicted Sulfur Dioxide Levels, by Averaging Period		
	Annual Average	Highest 24-Hour Average	Highest 1-Hour Average
1	59%	66%	59%
2	61%	70%	62%
3	48%	48%	57%
4	81%	82%	65%
5	68%	67%	62%
6	61%	52%	48%
7	71%	73%	52%
8	83%	74%	64%
9	70%	74%	57%
10	61%	60%	53%
11	60%	38%	46%
12	66%	67%	51%

Note:

- The table presents the predicted percent decrease in *SCC's contribution to* the measured concentrations. The actual percent decreases observed will differ slightly because of relatively small contributions from other sulfur dioxide emissions sources in the area.

Table 32. Predicted Annual Average Concentrations of “Total Particulates” Resulting from Stauffer Chemical Company’s Air Emissions

Location Number	Estimated Concentrations ($\mu\text{g}/\text{m}^3$) Before 1979		Estimated Concentrations ($\mu\text{g}/\text{m}^3$) After May 1979	
	Lower Kiln Emissions	Higher Kiln Emissions	Lower Kiln Emissions	Higher Kiln Emissions
1	1.2	1.9	0.8	1.1
2	2.3	3.4	1.6	1.9
3	0.8	1.2	0.6	0.8
4	3.7	5.8	1.9	2.2
5	7.3	10.9	4.6	5.6
6	1.7	2.5	1.1	1.4
7	4.5	6.6	2.8	3.3
8	2.9	4.4	1.6	1.8
9	2.5	3.7	1.6	1.9
10	2.4	3.7	1.6	2.1
11	1.3	2.00	0.9	1.1
12	1.4	2.24	0.9	1.1

Key:

$\mu\text{g}/\text{m}^3$ micrograms per cubic meter
 SCC Stauffer Chemical Company

Note:

- Predictions were made for two different time frames (before May 1979 and after May 1979) to evaluate air quality impacts from SCC’s reconfiguring the rotary kiln stack.
- The representativeness of the “total particulate” emissions data for the rotary kiln stack has been questioned. SCC site documents suggest that sulfur dioxide gases collected by the sampling impingers used in the stack tests converted to sulfate and were measured as particulate, rather than gaseous, emissions. In short, SCC suspected the rotary kiln emissions data have a positive measurement bias. The “lower kiln emissions” reflect air quality impacts if the measurement bias is assumed to be double the emission rate, as SCC estimates.

Table 33. Predicted Highest 24-Hour Average Concentrations of “Total Particulates” Resulting from Stauffer Chemical Company’s Air Emissions

Location Number	Estimated Concentrations ($\mu\text{g}/\text{m}^3$) Before May 1979		Estimated Concentrations ($\mu\text{g}/\text{m}^3$) After May 1979	
	Lower Kiln Emissions	Higher Kiln Emissions	Lower Kiln Emissions	Higher Kiln Emissions
1	18.1	29.4	11.4	14.9
2	41.9	62.8	25.8	30.6
3	15.6	23.1	12.0	15.9
4	53.1	87.5	24.1	29.4
5	82.7	121.6	51.6	60.4
6	21.1	29.7	15.0	17.3
7	55.5	84.0	32.9	38.9
8	48.7	75.6	27.5	33.3
9	49.5	75.8	27.8	32.4
10	33.3	53.2	23.9	30.0
11	13.8	21.0	10.7	15.0
12	26.5	40.2	16.8	20.8

Key:

$\mu\text{g}/\text{m}^3$ micrograms per cubic meter
 SCC Stauffer Chemical Company

Note:

- Predictions were made for two different time frames (before May 1979 and after May 1979) to evaluate air quality impacts from SCC’s reconfiguring the rotary kiln stack.
- The representativeness of the “total particulate” emissions data for the rotary kiln stack has been questioned. SCC site documents suggest that sulfur dioxide gases collected by the sampling impingers used in the stack tests converted to sulfate and were measured as particulate, rather than gaseous, emissions. In short, SCC suspected the rotary kiln emissions data have a positive measurement bias. The “lower kiln emissions” reflect air quality impacts if the measurement bias is assumed to be double the emission rate, as SCC has estimated.

Table 34. Index of Air Sampling Studies Conducted While the Stauffer Chemical Company Facility Operated (1948–1981)

Party That Initiated Sampling	Purpose of Sampling	Sampling Dates	Sampling Locations	Contaminants Measured	Overview of Sampling Results
PCDEM	Evaluate attainment status with EPA's National Ambient Air Quality Standards.	1977–2002	Two locations: one immediately southeast of SCC on Anclote Road, the other roughly 7 miles southeast of SCC ("East Lake Tarpon").	Sulfur dioxide	<p>Ambient air concentrations of sulfur dioxide at the Anclote Road monitoring station exceeded EPA's National Ambient Air Quality Standards in 1977, 1978, and 1979. The elevated concentrations have been attributed to emissions from SCC's rotary kiln stack. Annual average concentrations before a stack modification in 1979 were more than ten times higher than those measured after SCC shut down. One-hour average concentrations at the Anclote Road station exceeded 100 ppb several hundred times per year before the stack modification.</p> <p>Annual average sulfur dioxide concentrations at the East Lake Tarpon station in 1980–1981 were not considerably different from those measured since SCC shut down, suggesting that SCC's emissions had minimal air quality impacts at locations 7 miles from the facility.</p>
PCDEM	Evaluate attainment status with EPA's National Ambient Air Quality Standards.	1976–1990	Two locations: one immediately southeast of SCC on Anclote Road, the other roughly 7 miles southeast of SCC ("East Lake Tarpon").	TSP	<p>At the Anclote Road monitoring station, annual geometric mean TSP concentrations ranged from 60.2 to 73.2 $\mu\text{g}/\text{m}^3$ during years when SCC operated, and ranged from 40.7 to 51.2 $\mu\text{g}/\text{m}^3$ after the facility shut down. On average (based on arithmetic means), TSP levels decreased by 24 $\mu\text{g}/\text{m}^3$ after SCC shut down. Several measurements exceeded Florida's air quality standards, but none exceeded EPA's former TSP standards.</p> <p>At the East Lake Tarpon monitoring station, annual geometric mean TSP concentrations in 1979 and 1980 were 37.4 and 38.4 $\mu\text{g}/\text{m}^3$, respectively.</p>

**Table 34. Index of Air Sampling Studies Conducted While the Stauffer Chemical Company Facility Operated (1948–1981)
(continued)**

Party That Initiated Sampling	Purpose of Sampling	Sampling Dates	Sampling Locations	Contaminants Measured	Overview of Sampling Results
PCDEM	Analyze characteristics of particles collected on TSP filters.	1979	PCDEM's Anclole Road station, located immediately southeast of SCC	Filters were inspected for contributions from different source categories.	PCDEM hired an EPA contractor to examine the characteristics (e.g., particle types) of airborne particulate matter collected on at least 14 TSP filters from the Anclole Road monitoring station. In most of the samples considered, Stauffer's emissions were identified as the "cause" of the elevated TSP levels; in some samples, however, Stauffer's emissions were reportedly "a relatively minor source" of the measured TSP levels. Emissions sources other than SCC (e.g., mobile sources, the Anclole Power Plant) contributed, in varying amounts, to the airborne particles detected on the TSP filters.
SCC	The reasons for sampling were not always specified. One reason was to detect air quality impacts before they reached off-site locations.	1975–1982	The number and locations of sampling stations changed from year to year. In general, SCC measured sulfur dioxide levels at various locations along the perimeter of the facility property.	Sulfur dioxide	Limited inferences can be drawn from SCC's sulfur dioxide monitoring results, because the data are of questionable quality and because the data provided to date are incomplete. Several site documents acknowledge that SCC field personnel experienced problems operating the Philips Instruments sulfur dioxide monitors—problems that persisted for more than 2 years. Most site documents provide limited insights on quality control and quality assurance. The data quality concerns notwithstanding, SCC's monitoring results are reasonably consistent with PCDEM's. For instance, a monitoring summary indicated that 1-hour average sulfur dioxide concentrations in 1977 exceeded 100 ppb roughly one out of every 4 days along the facility boundary.

**Table 34. Index of Air Sampling Studies Conducted While the Stauffer Chemical Company Facility Operated (1948–1981)
(continued)**

Party That Initiated Sampling	Purpose of Sampling	Sampling Dates	Sampling Locations	Contaminants Measured	Overview of Sampling Results
SCC	Sampling was conducted for many reasons, but generally to characterize air quality impacts from SCC.	Periodically between 1964 and 1981.	Sampling locations varied from one survey to the next; in each survey, up to 10 sampling locations were employed.	Fluorides	SCC measured ambient air concentrations of fluorides in hundreds of samples collected before the facility shut down. Out of all SCC's field surveys, only a single 24-hour average fluoride concentration ($32.2 \mu\text{g}/\text{m}^3$) exceeded Agency for Toxic Substances and Disease Registry's minimal risk level for acute inhalation exposures ($20 \mu\text{g}/\text{m}^3$). The quality of the fluoride measurements is not known and cannot be assessed from the available information, because the site documents reviewed provide no insights on accuracy, precision, or quality assurance measures. As a result, drawing firm conclusions based solely on SCC's measurements is not advised.
SCC	Sampling was conducted for many reasons, but generally to characterize air quality impacts from SCC and from other local sources.	Periodically between 1964 and 1976; routinely in 1981; and possibly during other time frames not identified in the site documents.	Sampling locations varied from one survey to the next; in each survey, up to 10 sampling locations were employed.	Particulate matter. Most air quality surveys reported concentrations of "total particulates," without indicating the particle size fraction of this metric.	Since 1964, SCC has collected hundreds of particulate air samples. In the majority of samples, concentrations were reported as "total particulates," without specifying any information on particle size distribution. One sampling station was located in immediate proximity of PCDEM's Anclote Road monitoring station, but the "total particulate" concentrations reported for SCC's stations were consistently lower than the TSP concentrations reported by PCDEM. Almost every air quality survey that measured particulate matter concentrations lacks important details on study design and quality assurance measures, which greatly limit the inferences (if any) that can be drawn from these sampling results.

**Table 34. Index of Air Sampling Studies Conducted While the Stauffer Chemical Company Facility Operated (1948–1981)
(continued)**

Party That Initiated Sampling	Purpose of Sampling	Sampling Dates	Sampling Locations	Contaminants Measured	Overview of Sampling Results
SCC	Sampling was conducted for many reasons, but generally to characterize air quality impacts from SCC.	1964 and 1975	Ten off-site sampling locations at varying distance from the SCC facility.	Phosphorus pentoxide	The two air quality surveys measured phosphorus pentoxide concentrations at 10 offsite sampling locations. Average concentrations during the surveys ranged from 0.45 to 3.30 $\mu\text{g}/\text{m}^3$, and the highest concentration measured was 18.03 $\mu\text{g}/\text{m}^3$. Results are based on a particulate sampling method, which likely did not capture gaseous phosphorus pentoxide. It is not clear whether the methods used characterize particle-bound phosphoric acid or phosphorus pentoxide. Neither field survey provides data quality observations and it is unclear whether the surveys followed air sampling plans or quality assurance plans. For these and other reasons, drawing firm conclusions based solely on SCC's measurements is not advised.
Florida Power Corp.	To characterize air quality in the vicinity of the Anclote Plant.	1980. Monitoring was done in other years, but the results have not been located.	Four stations in northern Pinellas and southern Pasco Counties. One station was adjacent to PCDEM's Anclote Road monitoring station.	TSP	Florida Power Corporation operated an ambient air monitoring network as early as 1977. That network operated routinely, with some periods of inactivity, through 1998. However, the only results available for review are from 1980. Geometric mean TSP concentrations during this year ranged from 36 to 62 $\mu\text{g}/\text{m}^3$, with the highest levels detected adjacent to PCDEM's Anclote Road monitoring station. The highest 24-hour average concentration at this station was 185 $\mu\text{g}/\text{m}^3$. Although this ambient air monitoring network followed extensive quality control procedures in future years (1994–1998), it is unclear from the site documents whether these measures were in place in 1980. Therefore, the 1980 monitoring results from this network are of unknown quality.

Key: EPA U.S. Environmental Protection Agency
 $\mu\text{g}/\text{m}^3$ micrograms per cubic meter
 ppb parts per billion
 PCDEM Pinellas County Department of Environmental Management
 SCC Stauffer Chemical Company
 TSP total suspended particulates

Table 35. Sulfur Dioxide Levels Measured at the Ancote Road Monitoring Station

Year	1-Hour Average Concentrations			3-Hour Average Concentrations		24-Hour Average Concentrations		Annual Average Concentration (ppb)
	No. of Observations	No. of Hours with Levels >100 ppb	No. of Days with 1-Hour Average Levels >100 ppb	No. of Observations	No. of Days with 3-Hour Average Levels >500 ppb	No. of Observations	No. of Days with 24-Hour Average Levels >140 ppb	
1977	3,341	158	45	3,235	2	3,374	5	17.36
1978	7,384	287	77	7,040	3	7,540	8	14.64
1979	8,300	70	39	7,991	4	8,437	3	7.19
1980	7,878	54	29	7,504	0	8,041	0	5.68
1981	7,879	32	20	7,536	0	7,936	0	4.40
1982	8,030	3	2	7,638	0	8,194	0	1.47
1983	8,384	2	2	8,000	0	8,631	0	1.32
1984	8,514	0	0	8,164	0	8,722	0	1.14
1985	8,417	1	1	8,067	0	8,602	0	1.49
1986	8,538	0	0	8,335	0	8,629	0	1.68
1987	8,466	2	2	8,315	0	8,494	0	1.41
1988	8,579	0	0	8,479	0	8,620	0	1.71
1989	8,596	1	1	8,458	0	8,641	0	1.75
1990	8,502	0	0	8,348	0	8,567	0	1.46
1991	8,614	1	1	8,410	0	8,711	0	0.88
1992	8,582	0	0	8,452	0	8,593	0	1.33
1993	8,624	0	0	8,464	0	8,687	0	1.36
1994	8,637	3	1	8,469	0	8,737	0	1.13
1995	8,610	0	0	8,400	0	8,721	0	0.77
1996	6,801	1	1	6,671	0	6,881	0	0.89

Table 35. Sulfur Dioxide Levels Measured at the Anclote Road Monitoring Station (continued)

Key:

ppb parts per billion

Notes:

- Data source: EPA 2002a. All observations accessed were for continuous sulfur dioxide monitoring devices.
- The Anclote Road monitoring station began operating in July 1977 and stopped operating in October 1996. Therefore, the data presented for 1977 and 1996 are based on a partial year of ambient air monitoring data.
- Data for 1-hour average, 3-hour average, and 24-hour average are based on the raw figures for these averaging times reported to the Aerometric Information Retrieval System database (AIRS). Data for annual average concentrations were calculated from the set of 1-hour average observations. The raw data for 3-hour and 24-hour concentrations are running averages, meaning that each day sampling occurred can have as many as 24 observations for 3-hour average and 24-hour average concentrations.
- EPA's primary (or health-based) National Ambient Air Quality Standard for sulfur dioxide is 140 ppb for 24-hour average concentrations and 30 ppb for annual average concentrations (EPA 1995). EPA's secondary National Ambient Air Quality Standard for sulfur dioxide is 500 ppb for 3-hour average concentrations. This secondary air quality standard is not health-based, but rather protects against damage to property, impaired visibility, and other valued resources. A 1-hour average concentration of 100 ppb is the lowest acute exposure concentration that has been associated with adverse health effects in humans (persons with asthma), as documented in the Agency for Toxic Substances and Disease Registry's *Toxicological Profile for Sulfur Dioxide* (ATSDR 1998).

Table 36. Index of Air Sampling Studies Conducted After Stauffer Chemical Company Production Operations Ceased (1982–2002)

Party That Initiated Sampling	Purpose of Sampling	Sampling Dates	Sampling Locations	Contaminants Measured	Overview of Sampling Results
EPA	To determine whether the inactive site releases arsenic, fluorides, or radon to the air	November 1987	Five locations on SCC property; one off-site location	Arsenic Fluorides Radon TSP	TSP concentrations ranged from 22 to 30 $\mu\text{g}/\text{m}^3$; arsenic and fluorides were not detected; radon levels ranged from 0.1 to 2.2 pCi/L, and a control sample contained radon at 1.2 pCi/L.
Pasco County District School Board	To determine whether site demolition activities cause elevated levels of asbestos or phosphorus compounds in the air at Gulfside Elementary School	July and August 1987	Two outdoor and three indoor locations at the Gulfside Elementary School	Asbestos Elemental phosphorus Phosphoric acid Phosphoric pentoxide	Asbestos structures, phosphoric acid, and phosphorus pentoxide were not detected in any of the samples. Detection limits were reported as follows: asbestos, 0.005 structures per cubic centimeter; phosphoric acid, between 1 and 2 $\mu\text{g}/\text{m}^3$; and phosphorus pentoxide, between 1 and 2 $\mu\text{g}/\text{m}^3$. Elemental phosphorus was detected in only one of ten samples, and at a concentration of 11 $\mu\text{g}/\text{m}^3$.
PCDEM	Evaluate attainment status with EPA's National Ambient Air Quality Standards	1982–1989 1992–2002	Two locations: one immediately southeast of SCC, the other roughly 7 miles southeast of SCC	PM ₁₀ Sulfur dioxide TSP	Since 1981, all annual average and 24-hour average PM ₁₀ , sulfur dioxide, and TSP concentrations have been in attainment with EPA's primary air quality standards. The 3-hour average sulfur dioxide concentrations are in attainment with EPA's secondary air quality standards.

Table 36. Index of Air Sampling Studies Conducted After Stauffer Chemical Company Production Operations Ceased (1982–2002) (continued)

Party That Initiated Sampling	Purpose of Sampling	Sampling Dates	Sampling Locations	Contaminants Measured	Overview of Sampling Results
SCC	To determine whether site excavation activities release phosphorus compounds and asbestos into the air	May 28–29, 1997	One location upwind from the excavation, and one location downwind from the excavation	Asbestos Elemental phosphorus Phosphoric acid	On May 29, 1997, a single amosite asbestos structure was detected in an upwind sample (0.0033 structures per cubic centimeter), and a single chrysotile structure was detected in a downwind sample (0.0051 structures per cubic centimeter). Phosphoric acid was not detected in any sample, with detection limits ranging from 1 to 34 $\mu\text{g}/\text{m}^3$. Elemental phosphorus was detected in an upwind sample (2 $\mu\text{g}/\text{m}^3$) and in a downwind sample (3 $\mu\text{g}/\text{m}^3$).
SCC	To assess whether site remediation activities, mainly soil sampling, cause releases of asbestos into the air	March and April 1998	24 on-site locations around the perimeters of six former process areas, plus personal exposure samples	Asbestos	The highest time-weighted average asbestos level in the personal exposure sampling (determined by PCM) was 0.0073 fibers per cubic centimeter, which is less than NIOSH's recommended exposure level. No asbestos structures were identified in the personal exposure samples that were reanalyzed using TEM. The average asbestos concentration in the 24 ambient air samples was 0.00024 structures per cubic centimeter, as measured by TEM.

Table 36. Index of Air Sampling Studies Conducted After Stauffer Chemical Company Production Operations Ceased (1982–2002) (continued)

Party That Initiated Sampling	Purpose of Sampling	Sampling Dates	Sampling Locations	Contaminants Measured	Overview of Sampling Results
SCC	To ensure that the phosphorus drumming project did not cause unhealthy levels of air contamination	April to September 1997	At various on-site locations both upwind and downwind from the source areas	Dust Elemental phosphorus Phosphoric acid	Levels of “dust” (particle size fraction not specified) varied throughout the day, and 24-hour average concentrations ranged from 16 to 65 $\mu\text{g}/\text{m}^3$ —lower than EPA’s health-based standard for 24-hour average PM_{10} levels. Elemental phosphorus was detected in one sample, at 3 $\mu\text{g}/\text{m}^3$. Phosphoric acid was detected in roughly 40% of the samples—the highest detection was 4.62 $\mu\text{g}/\text{m}^3$.
Florida Power Corp.	To characterize air quality in the vicinity of the Anclote Plant	1994–1998	Three locations: one immediately southeast of SCC, another roughly 1 mile northeast of SCC, and another roughly 2 miles north of SCC	PM_{10} Sulfur dioxide TSP	From 1994 to 1998, all annual average and 24-hour average PMA_{10} , sulfur dioxide, and TSP concentrations have been in attainment with EPA’s primary air quality standards. The 3-hour average sulfur dioxide concentrations are in attainment with EPA’s secondary air quality standards.

Key:

EPA U.S. Environmental Protection Agency
 $\mu\text{g}/\text{m}^3$ micrograms per cubic meter
 NIOSH National Institute for Occupational Safety and Health
 PCDEM Pinellas County Department of Environmental Management
 pCi/L picocuries per liter
 PCM phase contrast microscopy
 PM_{10} particulate matter less than 10 μg in diameter

SCC Stauffer Chemical Company
 TEM transmission electron microscopy
 TSP total suspended particulates

Table 37. Stauffer Chemical Company Site, Completed Exposure Pathways

PATHWAY NAME	EXPOSURE PATHWAY ELEMENTS					TIME	COMMENTS
	Source	Environmental Media	Point of Exposure	Route of Exposure	Exposed Population		
Air (off-site)	Emissions from the roaster and furnace gas condensers, electric arc furnace tap holes, and nodulizing kiln	Air	Residences Commercial properties Schools	Inhalation	Area residents Students	Past	<p>Meteorologic records show that winds predominantly blew from the northeast to the southwest, although winds blowing in all directions at varying speeds were observed throughout the period of record. The least prevalent wind directions were from the south to the north, or the wind directions that would most likely blow emissions from site to the Gulfside Elementary School.</p> <p>During the years of plant operations, outdoor air monitoring detected primarily elevated concentrations of sulfur dioxide and particulates.</p>
Air (on-site)	See above	Air	Work areas	Inhalation	Former Stauffer workers	Past	Workers might have been exposed to emissions during routine work activities. Some worker monitoring data, conducted by Stauffer, are available (work area or personal monitors were examined for dusts, metals, fluorides, sulfur dioxide, and phosphorus).
On-site groundwater	Disposal ponds Slag processing area	Groundwater	On-site supply wells	Ingestion	Workers	Past Future	<p>On-site supply wells (from the Floridan Aquifer) were used to provide potable water during the years of Stauffer's operations. Since approximately 1979, the site has been served by public water, which is unaffected by Stauffer activities.</p> <p>Historic sampling data from supply wells did not reveal elevated levels of contaminants. On-site groundwater within the shallow aquifer has been affected by past site activities. Monitoring data reveal elevated concentrations of metals, fluoride, phosphorus, and radionuclides. Available data suggest that the deeper Floridan aquifer has not been affected by site activities (however, only a limited number of locations and samples were tested in the deeper aquifer).</p>

Table 37. Stauffer Chemical Company Site, Completed Exposure Pathways (continued)

PATHWAY NAME	EXPOSURE PATHWAY ELEMENTS					TIME	COMMENTS
	Source	Environmental Media	Point of Exposure	Route of Exposure	Exposed Population		
On-site surface soil and slag	Wastes generated site operations (e.g., calcium silicate slag, metals, furnace off-gas solids, phosphorous-containing sludge)	Soil/slag	Processing and surrounding areas	Incidental (accidental) ingestion	Former and current site workers	Past	Possible exposure to site soils is expected to be limited to on-site workers and occasional trespassers. Planned remedial actions should prevent future exposures. Historically, the majority of the site was fenced, with 24-hour security (NUS 1989). Access to the site continues to be restricted and accessible only to workers. The disposal areas between Anclote Road and Anclote Boulevard have not always been securely fenced; this disposal area is less than 2,000 feet from the Gulfside Elementary School. Past studies have shown elevated levels of contaminants in the on-site surface soils in and around the processing areas of the plant (most significantly in and around former disposal ponds, slag processing/storage areas, and production facilities).
				Skin contact	Remediation workers	Current	
				Inhalation of surface soil dusts	Trespassers	Future	
Off-site surface soil	Plant furnace emissions	Soil	Residences	Incidental (accidental) ingestion	Area residents	Past	Residential, commercial, and school properties are in the immediate vicinity of the Stauffer site. The Gulfside Elementary School abuts the site on the northern property boundary. The only off-site soil data collected was from the Gulfside Elementary School. No measured contaminants were detected at levels above CVs, except for radium-226. No soil sampling has occurred in areas in predominant downwind areas.
	Residual slag		Commercial properties	Skin contact	Employees	Current	
			Schools	Inhalation of surface soil dusts	Students	Future	

Table 37. Stauffer Chemical Company Site, Completed Exposure Pathways (continued)

PATHWAY NAME	EXPOSURE PATHWAY ELEMENTS					TIME	COMMENTS
	Source	Environmental Media	Point of Exposure	Route of Exposure	Exposed Population		
Off-site slag	Wastes generated from elemental phosphorus production	"Slag"	Roadways Building materials	Incidental (accidental) ingestion Skin contact Inhalation of dusts	Area residents, employees, and students	Past Current Future	Waste slag was used in the community in constructing roads and building materials. The waste slag was first shipped to off-site storage locations before distributing it for community use. In general, testing of slag materials revealed low levels of chemical and radiologic activity.
Surface water (Anclote River and Meyers Cove)	Groundwater discharge and site drainage	Surface water	Along the banks of the Anclote River	Incidental (accidental) ingestion Skin contact	Residents of and visitors to downstream areas	Past Current Future	Site drainage flows to the Anclote River, west to the Gulf of Mexico (~1.6 miles from the site). The river is not currently used for drinking water, however, a Pasco County Park is located 0.9 miles west on the Anclote River (NUS 1989). The river is used extensively for recreational and commercial activities including swimming, boating, and fishing. The site lagoon system is situated approximately 40 feet from the Anclote River and less than 0.5 miles from a shellfish harvesting area.
Sediment (Anclote River and Meyers Cove)	Groundwater discharge and site drainage	Sediment	Along the banks of the Anclote River	Incidental (accidental) ingestion Skin contact	Residents of and visitors to downstream areas	Past Current Future	As mentioned above, the Anclote River has a variety of recreational and industrial uses. Sediments were found to have the highest concentration of many contaminants in Meyers Cove, the area directly adjacent to the site. Meyers Cove is not used for recreational purposes; further, few contaminants exceed CVs. People would not come in contact with river sediments except perhaps infrequently along the immediate shore and possibly during the collection of shellfish.

Italicized text indicate aspects of the pathway for which data are uncertain, incomplete, or unavailable.

Key: CV comparison value SMC Stauffer Management Company

Table 38. Stauffer Chemical Company Site, Potential Exposure Pathways

PATHWAY NAME	EXPOSURE PATHWAY ELEMENTS					TIME	COMMENTS
	Source	Environmental Media	Point of Exposure	Route of Exposure	Exposed Population		
Off-site groundwater (Floridan aquifer)	<i>Not verified</i>	Deep groundwater	Residential and commercial potable wells	Ingestion Skin Contact	Residents Visitors	Past Current Future	<p>Groundwater in the area of the site (in Holiday and Tarpon Springs) is used for drinking water. All drinking water wells are believed to be in the deeper Floridan aquifer. Current data suggest that discharge of contaminated groundwater to the Anclote River (in the direction of groundwater flow) prevents any impact on downgradient private wells. The nearest private potable well is believed to be 2,500 feet northwest (upgradient) of the site. Commercial potable wells exist east (cross-gradient) of the site.</p> <p>Arsenic, chromium, lead, nickel, thallium, zinc, chlorides, sulfate, gross alpha radiation, and radium-226 were detected above Agency for Toxic Substances and Disease Registry CVs, but at relatively low frequencies.</p> <p>ATSDR considers this a potential exposure pathway because people are drinking water from areas wells. Though area wells are generally not believed to be in the path of groundwater contaminant flow from the site, ATSDR evaluated this pathway to understand the potential for exposure to harmful levels of contaminants and to address specific community concerns about the safety of drinking private well water in the vicinity of the site.</p>

Table 38. Stauffer Chemical Company Site, Potential Exposure Pathways (continued)

PATHWAY NAME	EXPOSURE PATHWAY ELEMENTS					TIME	COMMENTS
	Source	Environmental Media	Point of Exposure	Route of Exposure	Exposed Population		
Off-site groundwater (Shallow aquifer)	<i>Not verified</i>	Shallow groundwater	Irrigation wells	Skin	Residents Visitors	Past Current Future	Though irrigation wells also are not believed to be in the path of groundwater contaminant flow from the site, ATSDR evaluated this pathway to understand the potential for exposure to harmful levels of contaminants. Generally, limited potential likely exists for contact with water from irrigation wells. Arsenic, zinc, and chlorides were detected in some irrigation wells above <i>drinking water</i> CVs; however, detected concentrations are not expected to be of public health concern through skin contact.
On-site subsurface soil	Wastes generated from elemental phosphorus production	Soil	Disposal areas	Incidental (accidental) ingestion Skin contact Inhalation of dusts	Remediation workers	<i>Future</i>	On-site subsurface soils include those located on and around the main processing area, beneath the slag piles, and within the former disposal ponds. No past or current exposures exists, because soils are not accessible. Site cleanup plans which are still under negotiation will be developed and implemented with the goal of preventing future exposures.
Biota (Anclote River/Gulf of Mexico)	Contaminants in surface water and sediment	Fish Shellfish	<i>Fish/shellfish harvested from the river/gulf</i>	Ingestion	Recreational fishers Consumers of commercially harvested fish	Past Current Future	No sampling data (fish tissue) are available to evaluate possible impact of site contaminants on area fish/shellfish. However, the type of, location of, and detection frequency of contaminants reported in river and Meyers Cove sediments show that accumulation of contaminants in fish/shellfish tissue is not likely.

Table 38. Stauffer Chemical Company Site, Potential Exposure Pathways (continued)

PATHWAY NAME	EXPOSURE PATHWAY ELEMENTS					TIME	COMMENTS
	Source	Environmental Media	Point of Exposure	Route of Exposure	Exposed Population		
External gamma radiation	<i>Process waste and slag</i>		On-site and off-site areas Building and roadway materials		Workers Residents	Past Current Future	Community exposure to gamma radiation was the subject of a recent Agency for Toxic Substances and Disease Registry health consultation (ATSDR 2002), which concluded that doses from homes and pavement with slag are not elevated and do not pose a health threat. No conclusion can be made about the extent to which Stauffer site slag material is contained in surrounding community roads and buildings.

Italicized text indicate aspects of the pathway for which data are uncertain, incomplete, or unavailable.

Key:

CV comparison value
SMC Stauffer Management Company

Table 39. Hourly Sulfur Dioxide Levels at the Anclothe Road Monitoring Station When Stauffer Chemical Company Was Operating, Number of Samples Greater Than ATSDR's Acute Inhalation MRL of 10 ppb

Year	Hourly Average Concentrations		
	Number of 1-hour Samples	Number of 1-hour Samples Greater Than 10 ppb	Number of Days With Concentrations Greater Than 10 ppb
1977	3,341	507	96
1978	7,384	950	192
1979	8,300	783	194
1980	7,878	663	171
1981	7,879	564	156
Total	34,782	3,467	809

Key:

ppb parts per billion

Table 40. Summary of Studies Showing Effects to the Lung From Sulfur Dioxide Exposure in Persons With and Without Asthma. Pertinent Animal Studies Are Also Reported.

Sulfur Dioxide, ppb	Duration of Exposure, Minutes	Exposure Conditions	Effect End Point	Reference
8,000	20	Healthy persons without asthma	Redness of airways (trachea, bronchi), Increased inflammatory cells in fluids from lung	Sandstrom et al. 1989
5,000	10	Healthy persons without asthma, quiet mouth breathing	Increased air airway resistance	Lawther et al. 1975
5,000	10 to 30	Healthy persons without asthma	Cough, sense of irritation	Frank et al. 1962
4,000	20	Healthy persons without asthma	Increased number macrophages in fluid from lungs	Sandstrom et al. 1989
1,000	Not specified	Healthy persons without asthma	Increased airway resistance	Lawther et al. 1975
1,000	10	Healthy persons without asthma	Increased heart rate and breathing rate	Amdur et al. 1953
1,000	10	Mouthpiece, exercise, persons with mild asthma	Significantly Increased airway resistance Wheezing and shortness of breath (symptoms of bronchoconstrictions)	Sheppard et al. 1981
1,000	30	Mouthpiece, exercise, healthy adolescents without asthma	Small changes in pulmonary function tests	Koenig et al. 1982
1,000	30	Mouthpiece, exercise, adolescents with asthma	Changes in pulmonary function tests consistent with bronchoconstriction, shortness of breath and wheezing	Koenig et al 1981
950	3 hours	Intermittent periods	Coughing	Dodge 1985
600	immediate 10 20	Mouthpiece, hyperventilation, healthy persons without asthma	increased airway resistance and significant bronchoconstriction in 13 of 26 persons	Islam et al 1992
600	5	Chamber exposure, heavy exercise, persons with asthma	Significantly increased airway resistance	Linn et al. 1983

Table 40. Summary of Studies Showing Effects to the Lung From Sulfur Dioxide Exposure in Persons With and Without Asthma. Pertinent Animal Studies Are Also Reported.
(continued)

Sulfur Dioxide, ppb	Duration of Exposure, Minutes	Exposure Conditions	Effect End Point	Reference
500	10	Mouthpiece apparatus, exercise, persons mild with asthma	Significantly Increased airway resistance and bronchoconstriction in seven of seven subjects Wheezing and shortness of breath in three of seven subjects	Sheppard et al. 1981
500	10 to 75	Chamber, exercise, persons with mild asthma	Increased airway resistance, increase less significant with time, except in two subjects. One subject withdrew because of pronounced wheezing and tightness of chest	Roger et al, 1985
500	3 to 5	Mouthpiece apparatus, hyperventilation, persons with asthma	Increased airway resistance	Balmes et al. 1987
500	3	Mouthpiece apparatus, hyperventilation, persons with asthma, cold dry air	bronchoconstriction causing wheezing and shortness of breath in 6 of 7 people, 2 people requested bronchodilators after exposure	Bethel et al 1984
500	5	Mouthpiece apparatus, exercising asthmatics	bronchoconstriction at moderate and high but not low work rate	Bethel et al, 1983
500	5	Facemask (oronasal breathing), exercising asthmatic	bronchoconstriction at high work rate	Bethel et al 1983
400	5	Chamber exposure, heavy exercise, persons with asthma	Moderately increased airway resistance	Linn et al. 1983
250 (lowest exposure tested)	40 with 10 minutes as exercise	Chamber exposure, exercise, persons with asthma	Slight, but statistically significant, decrease in air flow rate	Schachter et al. 1984

Table 40. Summary of Studies Showing Effects to the Lung From Sulfur Dioxide Exposure in Persons With and Without Asthma. Pertinent Animal Studies Are Also Reported.
(continued)

Sulfur Dioxide, ppb	Duration of Exposure, Minutes	Exposure Conditions	Effect End Point	Reference
250 (only exposure tested)	5	Chamber exposure, moderate exercise, persons with asthma	Increased airway resistance	Bethel et al. 1985
250	3	Mouthpiece apparatus	Increased airway resistance	Myers, 1986a, 1986b
250	10	Mouthpiece apparatus, exercise, persons with mild asthma	Significantly Increased airway resistance in three of seven subjects No wheezing or shortness of breath	Sheppard et al. 1981
250 (lowest exposure tested)	10 to 75	Chamber exposure, exercise, persons with mild asthma	No increase in airway resistance	Roger et al. 1985
250 (lowest exposure tested)	10	Chamber exposure, exercise, persons with asthma	Reanalysis of Roger et al. 1985 data indicates airway effects in some subjects	Hortsman et al. 1986
200 (lowest exposure tested)	5	Chamber exposure, heavy exercise, persons with asthma	No increase in airway resistance	Linn et al. 1983, 1987
100 (only exposure tested)	40 with 10 minutes as exercise	Mouthpiece apparatus, moderate exercise, allergic adolescents (some with asthma)	No increase in airway resistance from SO ₂ alone; increase observed in combination with 68 µg/m ³ sulfuric acid	Koenig et al. 1989
100	10	Mouthpiece apparatus, moderate exercise, persons with mild asthma	Increased airway resistance in two of seven subjects	Sheppard et al. 1981
100	3	Mouthpiece apparatus; hyperventilation; cold, dry air; persons with asthma	Increased airway resistance	Sheppard et al. 1984

Table 41. Hourly Sulfur Dioxide Levels at the Ancote Road Monitoring Station When Stauffer Chemical Company Was Operating, Number of Samples Greater Than 100 ppb

Year	Hourly Average Concentrations		
	Number of 1-hour Samples	Number of 1-hour Samples Greater Than 100 ppb	Number of Days With Concentrations Greater Than 100 ppb
July to December 1977 ¹	3,341	158	45
all 1977 ²	6,682 ³	316	90
1978	7,384	287	77
1979	8,300	70	39
1980	7,878	54	29
1981	7,879	32	20
Total from actual sample measurements (7/1/1977 through 12/31/1981).	34,782	601	210

¹Air monitoring began at the Ancote Road monitoring station in July 1977; therefore, the data presented in this row are actual measurements.

²The data presented for all of 1977 is estimated based on actual measurements from July to December 1977.

³Estimated.

Table 42. Frequency of Significantly Elevated Hourly Sulfur Dioxide Levels at the Anclote Road Monitoring Station in Relation to Wind Direction

Year	No. Hours Downwind at the Anclote Road Monitoring Station	No. Hours Above 100 ppb Sulfur Dioxide and Known Wind to the Southeast	Frequency in Percent
January to May 1979	720	48	6.7
1979	1,577	57	3.6
1980	1,687	50	3.0
1981	1,558	27	1.7

Table 43. Estimated Number of Hours That Hourly Sulfur Dioxide Levels Might Have Exceeded 100 ppb in Four Areas from January to May 1979.

Direction from Kiln	Geographic Area	January to May 1979		
		No. Hours Wind Blows to Each Location	Estimated Percent of Time That Levels Exceed 100 ppb	Estimated No. Hours Sulfur Dioxide Is Above 100 ppb
Southwest	Residences southwest of Stauffer who live along the shore of the Anclote River	785	6.7	52
West	Residences west of Stauffer	908	6.7	60
East	Businesses east of Stauffer	575	6.7	38
North	The slag processing area north of the kiln but still part of Stauffer ¹	463	6.7	31

¹Gulfside Elementary School is another 1,000 feet north of the former slag processing area.

Table 44. Annual Average Sulfur Dioxide Levels From 1977 to 1982

Year	Sulfur Dioxide Level* (parts per billion)
1977	17
1978	15
1979	7
1980	6
1981	4
1982	1

*Sulfur dioxide levels are rounded to the nearest whole number. The exact level can be found in Table 35.

Table 45. Predicted Maximum Hourly Sulfur Dioxide Levels, 1977 to 1981, at Various Locations Around Tarpon Springs

Location*	Description	Predicted Maximum Hourly Sulfur Dioxide Levels (ppb)**
1	North-northwest of Stauffer facility, in Pasco County	629
2	Gulfside Elementary School	1,052
3	Residential neighborhood in southern Pasco County, northeast of Stauffer facility	526
4	Residential neighborhood west of Stauffer facility	1,052
5	Industrial complex east of Stauffer facility	1,167
6	Piney Point, on the shore of the Gulf of Mexico	412
7	Residential neighborhood southwest of Stauffer facility, and in prevailing downwind direction	824
8	Anclote Road monitoring station near the Flaherty Marina	1,144
9	Residential neighborhood south of Stauffer facility	847
10	Residential neighborhood south-southwest and further downwind of Stauffer facility	561
11	Howard Park, on the shore of the Gulf of Mexico	400
12	Residential neighborhood southeast of Stauffer facility	618

*See Figure 19, Appendix A

** parts per billion

Table 46. Predicted Annual Average Sulfur Dioxide Levels, 1977 to 1981, at Various Locations Around Tarpon Springs

Location*	Description	Predicated Annual Average Sulfur Dioxide Levels (ppb)**	
		1977 to April 1979	May 1979 to 1981
1	North-northwest of Stauffer facility, in Pasco County	4	2
2	Gulfside Elementary School	7	3
3	Residential neighborhood in southern Pasco County, northeast of Stauffer facility	3	1
4	Residential neighborhood west of Stauffer facility	13	3
5	Industrial complex east of Stauffer facility	23	7
6	Piney Point, on the shore of the Gulf of Mexico	6	2
7	Residential neighborhood southwest of Stauffer facility, and in prevailing downwind direction	14	4
8	Anclote Road monitoring station near the Flaherty Marina	9	2
9	Residential neighborhood south of Stauffer facility	8	2
10	Residential neighborhood south-southwest and further downwind of Stauffer facility	8	3
11	Howard Park, on the shore of the Gulf of Mexico	4	2
12	Residential neighborhood southeast of Stauffer facility	5	2

* See Figure 19, Appendix A

** parts per billion, levels are rounded to the nearest whole number

Table 47. Summary of Recent Important Epidemiologic/Controlled Human Particulate Matter Exposure Studies of Specific Physiologic End Points

Physiologic End Point	Observed Association With Particulate Matter Exposure	Reference
Lung function	Small declines in lung function; large risk of substantial decrements Growth of lung function in children reduced	Pope 2000 Gauderman et al. 2000
Hypoxemia	No clear associations with blood oxygen saturation	Pope et al. 1999
Plasma viscosity	Increased risk of elevated blood plasma viscosity	Peters et al. 1997
Heart rate	Increased mean heart rate and odds of substantially elevated heart rate	Pope et al. 1999 Peters et al. 1999
Heart rate variability	Changes in cardiac rhythm Decrease in overall heart rate variability	Liao et al. 1999 Pope et al. 1999 Gold et al. 2000
Pulmonary inflammation	Elevated white blood cell counts, band cells expressed as percent of polymorphonuclear leukocytes, neutrophils, platelets, lymphocytes, and/or eosinophils	Tan et al. 2000 Salvi et al. 1999 Ghio et al. 2000
RBC sequestration	Changes in hemoglobin adjusted for albumin suggest that inhalation of some component of particulate matter may cause sequestration of red cells in the circulation by changes in RBC adhesiveness	Seaton et al. 1999
Heart arrhythmia	Increased risk of implanted cardioverter-defibrillator discharges	Peters et al. 2000

Partially adapted from Pope (2000).

Table 48. Estimated PM₁₀ Levels Based on TSP Levels Measured at the Ancote Road Monitoring Station From 1977 to 1989

Year	TSP ($\mu\text{g}/\text{m}^3$)	Estimated PM ₁₀ ($\mu\text{g}/\text{m}^3$)	Estimated Overall Average PM ₁₀ ($\mu\text{g}/\text{m}^3$)
SCC Facility Open			
1977	60	30	34
1978	65	33	
1979	70	35	
1980	73	37	
1981	71	36	
SCC Facility Closed			
1982	46	23	24
1983	46	23	
1984	51	26	
1985	51	26	
1986	49	25	
1987	48	24	
1988	49	25	
1989	41	20	

Key:

$\mu\text{g}/\text{m}^3$ micrograms per cubic meter

TSP total suspended particulates

PM₁₀ particulate matter less than 10 micrometers in diameter

Table 49. Estimated PM_{2.5} Levels at the Anclote Road Monitoring Station From 1977 to 1989

Year	Estimated PM ₁₀ (µg/m ³)	Estimated PM _{2.5} (µg/m ³)	Overall Estimated Average PM _{2.5} (µg/m ³)
SCC Facility Open			
1977	30	18	20
1978	33	20	
1979	35	21	
1980	37	22	
1981	36	21	
SCC Facility Closed			
1982	23	14	14
1983	23	14	
1984	26	15	
1985	26	15	
1986	25	15	
1987	24	14	
1988	25	15	
1989	20	12	

Key:

$\mu\text{g}/\text{m}^3$ micrograms per cubic meter

PM₁₀ particulate matter less than 10 micrometers in diameter

PM_{2.5} particulate matter less than 2.5 micrometers in diameter

Table 50. Summary of Epidemiologic Evidence of Health Effects of Acute Exposure to Particulate Matter Air Pollutants

Health End Points	Observed Association with Particulate Matter
Episodes of death and hospitalizations	Elevated respiratory and cardiovascular mortality and hospitalizations.
Mortality (death)	Elevated daily respiratory and cardiovascular mortality counts. Effects persisted with various approaches to control for time trends, seasonality, and weather. Near-linear associations with little evidence of threshold.
Hospitalization and other health-care visits	Elevated hospitalizations, emergency room visits, and clinic/outpatient visits for respiratory and cardiovascular disease. Effects generally persisted with various approaches to control for time trends, seasonality, and weather.
Symptoms/lung function	Increased occurrence of lower respiratory symptoms, cough, and exacerbation of asthma. Only relatively weak associations with respiratory symptoms. Small, often significant declines in lung function.

Adapted from Pope (2000).

Table 51. Summary of Arsenic and Lead Levels in Private Wells Near the Stauffer Chemical Company Site

Contaminant	Maximum Level in ppb	Date	Comments
Arsenic	26 and 23 (commercial)	March 2000	Levels in the remaining commercial and residential wells were less than the federal drinking water standard of 10 ppb.
	24 (residential, Pasco County)		
Lead	270 (residential)	March 2001	Other private wells contained 160, 24, and 18 ppb lead. The remaining residential and all commercial wells were below the lead drinking water standard of 15 ppb.

Key:

ppb parts per billion

Table 52. Summary of Arsenic Levels in On-Site Surface Soils, Pond Soils, and Slag

Media	No. Samples			Arsenic Levels, ppm	
	Above ATSDR CV	With Detectable Arsenic	Collected	Average	Maximum
Surface Soils	30	32	91	20	140
Pond Soils	48	48	59	122	340*
Slag	1	2	11	2	4.2

Key:

ATSDR Agency for Toxic Substances and Disease Registry

CV comparison value

ppm parts per million

*estimated concentration

Table 53. Estimated Dose of Arsenic in Children From Exposure to On-Site Surface Soils, Pond Soils, and Slag

Age Group	Surface Soils, μg/kg/day	Pond Soils, μg/kg/day	Slag, μg/kg/day
1-year-old child	0.28	1.7	0.028
Preschool children	0.18	1	0.017
Elementary school children	0.039	0.23	0.0039
Teenagers	0.025	0.15	0.0025
Adult men	0.02	0.12	0.002
Adult women	0.023	0.14	0.0023
Minimal risk level	0.3	0.3	0.3
Highest level not harmful	0.8	0.8	0.8
Lowest harmful level	14	14	14

Key:

μg/kg/day milligrams per kilogram per day
MRL minimal risk level

Note:

Average arsenic levels, in parts per million, are as follows:

- 20 ppm in surface soil
- 122 ppm in pond soil
- 2 ppm in slag.

Table 54. Theoretical Risk of Cancer from Arsenic in Soil

Media	Average Arsenic Level, Parts per Million	Estimated Number of Cancers*	Theoretically Exposed Population
Background for Florida	1	0 to 3	1,000,000
Background for eastern United States	7	0 to 20	1,000,000
On-Site Surface soils	20	0 to 50	1,000,000
On-Site Pond soils	122	0 to 300	1,000,000

*Numbers are rounded

Table 55. List of Area/Job Classification Categories for Stauffer Chemical Company, Tarpon Springs

Area Name	Job Classifications
Yard Department	Yard Labor, Diesel Equipment Operator, Switcher, Truck Driver, Janitor, Foreman
Kiln Department	Kiln Operator, Kiln Helper, Raw Materials Operator, Kiln Utility Person, Kiln Relief Operator
Furnace Department	Furnace Operator, Tapper, Utility Person, Furnace Relief Operator, Shift Foreman, Mudmill Operator (historic classification, not current)
P ₄ Handling Department	P ₄ A Operator, P ₄ B Operator, Pond Clarifier, Drum Loader
Laboratory Department	Analyst, Sampler, Chemist
Mechanical Department	Lubrication Mechanic, Mechanic Leadmen, Mechanics, Painters, Electrical Leadmen, Electricians, Storeroom Clerk, Mechanical Foreman, Electrical Foreman, Storeroom Foreman, Pollution Mechanic
Plant (General)	Supervision, All Personnel

Key:

P₄ Phosphorus

Table 56. Worker Exposure Concentrations and Limits From Stauffer Chemical Company, Tarpon Springs, Monitoring Data

Contaminant	Concentration		Area/Job Classification or Area and Specific Location	Protect Equip. Used	Type	Year	Freq	Date Range
	Minimum	Maximum						
Arsenic	<0.01 $\mu\text{g}/\text{m}^3$	<0.5 $\mu\text{g}/\text{m}^3$	Furnace Department, Furnace Operator	N	TWA	1978	43	1975-1978
Arsine	ND	0.05 ppm	P ₄ Handling Department, Condenser Deck	N	Grab	1975	6	1975
Asbestos	ND	0.33 f/cc	Storeroom, Asbestos Room	N/S [†]	N/A	1976	13	1975-1976
Carbon Monoxide	0 ppm	>700 ppm	Furnace Department, Rotoclone Collection	N	Grab	1975	96	1974-1980
Fluoride	0.00583 mg/m ³	0.5 mg/m ³	Kiln Department, Kiln Operator	N	EXC	1975	14	1975-1979
Hydrogen Sulfide	26 ppm	>60 ppm	P ₄ Handling Department, P ₄ Tank Car	N	Grab	1978	3	1978
Hydrogen Fluoride	0 ppm	0 ppm	Furnace Department, Furnace Building Roof	N	Grab	1977	1	1977
Iron Oxide	0.01 mg/m ³	1.82 mg/m ³	Mechanical Department, Mechanics	C	TWA	1981	12	1981
Lead	50 $\mu\text{g}/\text{m}^3$	423 $\mu\text{g}/\text{m}^3$	Mechanical Department, Painters	C	TWA	1981	4	1981
Ni (Sol/Metal)	<0.01 mg/m ³	0.26 mg/m ³	Mechanical Department, Mechanics	C	TWA	1981	8	1981
Nuisance dust: silica [†]	<0.052 mg/m ³	3.94 mg/m ³	Furnace Department, Burden Bins	N	Area	1975	3	1975
Oxygen	18.8%	21.0%	P ₄ Handling Department, P ₄ Tank Car	N	Grab	1978	80	1974-1980
P ₂ O ₅ /H ₃ PO ₄	0.05 mg/m ³	4.99 mg/m ³	P ₄ Handling Department, P ₄ A Operator	C	TWAN	1981	31	1981
Phosphine	ND	>7 ppm	P ₄ Handling Department, P ₄ Tank Car	N	Grab	1978	10	1975-1978
Phosphoric Acid: "filter (leach)"	ND	4.06 mg/m ³	P ₄ Handling Department, Condenser Deck	N	Grab	1979	15	1977-1979
Phosphorus (P ₄)	ND	88.9 $\mu\text{g}/\text{m}^3$	P ₄ Handling Department, Pond Clarifier	N	N/A	1975	16	1975-1977
Phosphorus-Yellow	3.04 $\mu\text{g}/\text{m}^3$	255.67 $\mu\text{g}/\text{m}^3$	P ₄ Handling Department, P ₄ B Operator	C	PAR	1979	48	1976-1981
Quartz	<6.2 $\mu\text{g}/\text{m}^3$	74.7 $\mu\text{g}/\text{m}^3$	Furnace Department, Utility Person	C	TWA	1980	56	1980
Quartz-T	220.3 $\mu\text{g}/\text{m}^3$	1,392 $\mu\text{g}/\text{m}^3$	Yard Department, Yard Labor	C	TWA	1979	7	1979-1980

Table 56. Worker Exposure Concentrations and Limits From Stauffer Chemical Company, Tarpon Springs, Monitoring Data (continued)

Contaminant	Concentration		Area/Job Classification or Area and Specific Location	Protect Equip. Used	Type	Year	Freq	Date Range
	Minimum	Maximum						
Respirable Dust	0.03 mg/m ³	15.6 mg/m ³	P ₄ Handling Department, P ₄ Operator	N	Area	1975	56	1975–1980
Silica Mixt-T	103%	604% [§]	Yard Department, Yard Labor	C	TWA	1979	7	1979–1980
Silica Mixture	<1%	148% [§]	Furnace Department, Utility Person	C	TWA	1980	55	1975–1980
Sulfur Dioxide	ND	1.39 ppm	Mechanical Department, Pollution Mechanic	C	TWA	1981	59	1979–1981
Total Dust	3.05 mg/m ³	590 mg/m ³	Kiln Department, Feed End	N/S	N/A	1972	7	1972–1980
Total Chromium	<0.01 mg/m ³	0.46 mg/m ³	Mechanical Department, Mechanics	C	TWA	1981	8	1981

[§]The concentration is expressed as a percentage of the PEL. OSHA's PEL when the facility operated was 100%. According to site documents, silica mixture is a combination of quartz and respirable dust exposures.

[†]Document does not give protective equipment code, but refers to the use of "OSHA-Approved Respirator."

[‡]Calculated value, based on level of nuisance dust (mg/m³) and percent silica content.

Key:

Protect Equip. (Protective Equipment) Code

N - None

C - half-face air-purifying respirator

N/S - Not Specified

Concentration Units

μg/m³ - micrograms per cubic meter

mg/m³ - milligrams per cubic meter

ppm - parts per million

f/cc - fiber per cubic centimeter

% - percent

Other Abbreviations

EXC - excursion sample, short-term breathing zone sample of 10–60 minutes

N/A - not available

ND - not detected

OSHA - Occupational Safety and Health Administration

PAR - partial shift breathing zone sample of 60–360 minutes duration

PEL - permissible exposure limit

TWA - time-weighted average

TWAN - full shift breathing zone sample that is not representative of typical plant operations

Table 57. Contaminants Exceeding an Occupational Standard or Agency for Toxic Substances and Disease Registry Comparison Value at Stauffer Chemical Company in Tarpon Springs

Contaminant	Maximum Concentration	Threshold Limit Value	Comparison Value
Arsenic	< 0.5 µg/m³ or 0.0005 mg/m³	0.01mg/m³ TWA	0.0002 µg/m³ CREG
Asbestos	0.33 f/cc or 10 µg/m³	0.1 f/cc TWA	0.000004 µg/m³ CREG
Carbon Monoxide	> 700 ppm	25 ppm TWA	None
Hydrogen Sulfide (H₂S)	>60 ppm or 60,000 ppb	10 ppm TWA	30 ppb EMEG I 70 ppb EMEG A
Lead	423 µg/m³ or 0.423 mg/m³	0.05 mg/m³ TWA	None
Nickel (Sol/Metal)	0.26 mg/m³ or 260 µg/m³	0.1 mg/m³ TWA	0.2 µg/m³ MRL C
Phosphine	>7 ppm or 0.0009 µg/m³	0.3 ppm TWA	0.3 µg/m³ RFC
Phosphoric Acid: "filter (leach)"	4.06 mg/m³ or 4,060 µg/m³	1 mg/m³ TWA	10 µg/m³ RFC I
Phosphorus (P₄)	54.12 µg/m³ or 0.054 mg/m³	0.1 mg/m³ TWA	20 mg/m³ MRL A
Phosphorus-Yellow	255.67 µg/m³ or 0.255 mg/m³	0.1 mg/m³ TWA	20 mg/m³ MRL A
Quartz	74.7 µg/m³ or 0.0747 mg/m³	0.05 mg/m³ TWA	None
Quartz-T	355.3 µg/m³ or 0.3553 mg/m³	0.05 mg/m³ TWA	None
Respirable Dust	15.6 mg/m³	5 mg/m³ TWA Resp	None
Silica Mixt-T	604%†	100%†	None
Silica Mixture	148%†	100%†	None
Sulfur Dioxide (SO₂)	1.39 ppm or 1,390 ppb	2 ppm TWA Resp 5 ppm TWA STEL	10 ppb EMEG A
Total Dust	590 mg/m³	10 mg/m³ TWA	None

Table 57. Contaminants Exceeding an Occupational Standard or Agency for Toxic Substances and Disease Registry Comparison Value at Stauffer Chemical Company in Tarpon Springs (continued)

Contaminant	Maximum Concentration	Threshold Limit Value	Comparison Value
Total Chromium	0.46 mg/m ³ or 460 µg/m ³	0.01 mg/m ³ TWA CrVI	0.01 µg/m ³ RFC

Key:

Concentration Units

µg/m³ - micrograms per cubic meter

mg/m³ - milligrams per cubic meter

ppm - parts per million

ppb - parts per billion

f/cc - fiber per cubic centimeter

% - percent

Other

A - Acute

C - Chronic

CREG - cancer risk evaluation guide

EMEG - environmental media evaluation guide

I - Intermediate

MRL - Minimal Risk Level

OSHA - Occupational Safety and Health Administration

PEL - permissible exposure limit

RFC - Reference Concentration

STEL - short-term exposure limit

TWA - Time Weighted Average

*The concentration is expressed as a percentage of the PEL. OSHA's PEL when the facility operated was 100%. According to site documents, silica mixture is a combination of quartz and respirable dust exposures.

Table 58. Theoretical Cancer Risks from Stauffer Occupational Exposures

Contaminant	Increased Risk (Quantitative)	Increased Risk (Qualitative)	Class
Asbestos	9.9E-04	Moderate	A
Chromium	7.2E-02	Significant	A

Sample Equation: $C \times EF \times ED \times CSF$

Assumptions for calculations:

Exposure frequency was 50 days per year (1 day per week, 50 weeks per year) and 8 hours per day

Exposure duration was 20 years

Cancer Risk Discussion

There is insufficient knowledge of cancer mechanisms to decide whether a level of exposure to a cancer-causing agent exists below which there is no risk for cancer (namely, a threshold level). Therefore, exposure to a cancer-causing compound, even at low concentrations, is assumed to be associated with some increased risk for evaluation purposes. It is assumed that as the dose of a carcinogen decreases, the chance of cancer also decreases.

The U.S. Environmental Protection Agency (EPA) classifies chemicals as Class A, Class B, Class C, Class D, or Class E. This classification defines a specific chemical's ability to cause cancer in humans and animals. This classification system been adapted from the International Agency for Research on Cancer (IARC). These EPA classifications are defined as follows:

- Group A Chemicals that are known human carcinogens.
- Group B Chemicals that are probable human carcinogens. Class B is further subdivided into two groups:
 - Group B1 Chemicals for which there is limited evidence of carcinogenicity from epidemiologic studies in humans
 - Group B2 Chemicals for which there is sufficient evidence of carcinogenicity in animals, but inadequate evidence or no data available from epidemiologic studies in humans.
- Group C Chemicals that are possible human carcinogens.
- Group D Chemicals that are not classifiable as to human carcinogenicity.
- Group E Chemicals for which there is evidence that they are not carcinogenic to humans.

For carcinogenic substances, EPA established the cancer slope factor (CSF), also referred to as cancer potency estimates, for exposure evaluation. CSF is used to determine the number of excess cancers resulting from exposure to a contaminant. The National Toxicology Program, in its *Biennial Report on Carcinogens* classifies a chemical as a "known human carcinogen" based on sufficient human data. Its classification of a chemical as being "reasonably anticipated to be a carcinogen" is based on limited human or sufficient animal data. The Agency for Toxic Substances and Disease Registry considers the above physical and biological characteristics when developing health guidelines for cancer-causing substances.

Table 58. Theoretical Cancer Risks from Stauffer Occupational Exposures (continued)

Increased cancer risk was estimated by using information about exposure levels for the contaminant of concern and multiplying by the chemical-specific CSFs to calculate a theoretical excess cancer risk estimate. An increased excess lifetime cancer risk is not a specific estimate of expected cancers. Rather, it is an estimate of the increase in the probability that a person might get cancer sometime in his or her lifetime after exposure to that contaminant.

Because of the uncertainties regarding the mechanism of cancer, varying suggestions exist among those in the scientific community about an acceptable excess lifetime cancer risk. The recommendations of many scientists have been in the risk range of one in one million to one in ten thousand (as referred to as 1×10^{-6} to 1×10^{-4}) excess cancer cases. An increased lifetime cancer risk of one in one million or less is generally considered an insignificant increase in cancer risk. An important consideration when determining cancer risk estimates is that the risk calculations incorporate a number of very conservative assumptions that are expected to overestimate actual exposure scenarios.

**APPENDIX C – DETAILED DISCUSSION OF SITE SAMPLING INVESTIGATIONS AND
ENVIRONMENTAL CONTAMINATION DATA**

DETAILED DISCUSSION OF SITE SAMPLING INVESTIGATIONS AND ENVIRONMENTAL CONTAMINATION DATA

This appendix contains detailed information on the sampling studies, environmental contaminant data, and data trends that ATSDR evaluated for the public health assessment. The information presented here supplements that discussed in the Environmental Contamination and Other Hazards section of the public health assessment.

C.1. On-Site Contamination

C.1.1. Soil

Surface and subsurface soil data were collected at and near the Stauffer Chemical Company (SCC) site during a number of site investigations including

- *Expanded site investigation (ESI) (1988)*: to collect soil and water samples from on- and off-site locations to support EPA's completion of hazard ranking system (HRS) documentation (NUS 1989).
- *Listing site inspection (1989)*: to augment existing data to provide the necessary data for a scoring of the site using the revised HRS (NUS 1991).
- *Site soil characterization study (1990)*: to conduct extensive characterization of site soils, including radiologic evaluations (PBS&J 1990; Weston 1990a, 1990b).
- *Environmental sampling program (1990)*: follow-up sampling activities to sampling reported by Weston (1990a, 1990b) to further characterize soils for radium-226 and various organic and inorganic constituents (Weston 1990c).
- *Elemental phosphorus borings program (1991)*: to identify phosphorus associated with buried wastes (Weston 1991).
- *RI (1993)*: to confirm the results of past investigations and address identified data gaps to more completely delineate the nature and extent of site contamination (Weston 1993).
- *Gulfside Elementary School environmental monitoring program (1996–1997)*: to evaluate conditions of the surface soils at Gulfside Elementary School, which is directly north of the SCC site (Weston 1996; EE&G 1997a, 1997b).
- *Soil/slag leachability study (1997)*: to determine the extent of contaminant leaching from soil and slag in the slag processing area (Parsons 1997).
- *Radiologic incident reports (1997–1998)*: set of 28 radiologic incident final reports summarizing findings of "slag" radiation concentrations in several area homes, schools, and businesses (FDOH 2002).

- *Sitewide asbestos sampling (1998)*: as a follow up to the sampling conducted as part of the Parsons 1997 study. A comprehensive survey of the site soils for the presence of asbestos (Parsons 1998).
- *Slag sampling (1998)* to identify radiologic and nonradiologic contaminants in specified households, schools, driveways, yards, and area roadways (EPA 1999a).
- *Background levels of arsenic and beryllium (1999)*: to sample soils from undisturbed on-site areas to better characterize on-site background arsenic and beryllium levels (Parsons 1999).

Six categories of “soils” were sampled during one or more of these investigations:

- surface and subsurface soils from the former ponds and an on-site drainage ditch,
- on-site slag material (e.g., surface soils from the slag pits and storage area, as well as roadway materials),
- surface and subsurface soils from other areas of the site,
- on-site asbestos sampling of surface and subsurface soils,
- off-site soils (including data from the Gulfside Elementary School), and
- off-site building materials containing slag.

C.1.1.1. Former Pond Soils and Dredged Soils

The following soil sampling programs were conducted as part of site investigations and include analyses of soils or dredge material taken from the former ponds. Not all of the samples obtained for each study were analyzed for the same contaminants.

Because several sampling events were conducted by different investigators, the designation of the sampling locations has changed over the years. Table 2 in Appendix B describes the pond designations used in the various studies. Both Table 1 and Figure 4 (in Appendix B) use the pond designations from the *Site Soil Characterization Study* (PBS&J 1990, Weston 1990a, 1990b).

- In January 1988, NUS Corporation collected eight samples from former ponds and dredge piles as part of an ESI. These eight samples were as follows: two composited surface soil samples from two former ponds; two subsurface samples (from the “saturated zone”) from two ponds; one composited surface soil sample from one dredge pile; and three samples from a second dredge pile, each taken at a different subsurface depth (4, 10, and 15 feet). Three samples were also obtained from a drainage ditch running along the northwest border of the site down into Meyers Cove. Samples were analyzed for EPA Contract Laboratory Program (CLP) organics and inorganics (NUS 1989).
- In April 1989, NUS Corporation collected additional surface and subsurface soil samples from six of the ponds, as well as from the two piles of dredged pond material. Three samples were taken from each pond/pile. Samples were analyzed for target analyte list (TAL) inorganics (NUS 1991).

- In November 1989, Post, Buckley, Schuh, Jernigan, Inc. (PBS&J) conducted a radiologic evaluation of the site. PBS&J performed an EGR survey of several areas of the site, including the former settling ponds in the southeast property and the dredged material piles. The surface and subsurface pond and dredged material soils were also analyzed for the presence of radium-226 (PBS&J 1990). This study is documented as part of the *Site Soil Characterization Study* (Weston 1990b).
- Between December 1989 and April 1990, Weston was contracted to perform soil sampling activities at the site. Composite depth samples were collected from 16 of the ponds and analyzed for arsenic, cadmium, chromium, lead, cyanide, fluoride, chloride, total phosphorus, and radium-226. Six of these ponds were also analyzed by the environmental pollutants (EP) toxicity and toxicity characteristic leaching procedure (TCLP) tests for the RCRA metals. Soils from four of these ponds were analyzed for radium-226 at the surface, midpoint, and bottom of their respective borings. Each of the 17 former pond areas were examined to determine the presence of elemental phosphorus (Weston 1990a). This study is documented as part of the *Site Soil Characterization Study* (Weston 1990b).
- In September 1990, Weston performed additional sampling of the surface soils from two of the ponds. These samples were analyzed for hazardous substance list (HSL) organics and inorganics (Weston 1990c).
- In June 1991, Weston performed additional borings in and around the areas of the former ponds to determine the presence of elemental phosphorus (Weston 1991).
- In March 1993, Weston analyzed four surface soil samples taken from three ponds, as well as one surface soil sample taken from a previous location of dredged pond material on the southeast property. This sampling was performed as part of the RI. The samples were analyzed for TAL metals, cyanide, fluoride, phosphorus, and total compound list (TCL) VOCs, SVOCs, pesticides and PCBs (Weston 1993).

Table 2 in Appendix B summarizes the findings of these pond and dredged material soil studies. The pond data summarized here include both surface soil and subsurface soil samples.

Highlights of the Table 2 data summary are presented here, including observed trends and details of sample locations:

- Five VOCs were detected in at least one of the eight samples. All detected VOCs were well below the ATSDR CVs. Acetone and methylene chloride were detected in more than half of the samples. The remaining VOCs were each detected in only one or two samples.
- Thirteen SVOCs were detected in at least one sample of the eight that were analyzed. Benzo[a]pyrene was detected slightly above the CV (0.1 ppm) in three samples with concentrations between 0.11 and 0.15 ppm. These samples were surface soils taken from ponds 49a, 49c, and 49D. Surface soil collected from pond 48 in March 1993 contained

concentrations of three SVOCs at concentrations above their respective CVs: benzo[a]anthracene, benzo[b]fluoranthene, and indeno[1,2,3-cd]pyrene.

The remaining SVOC concentrations were below ATSDR CVs. Five SVOCs were detected in at least 50 % of the samples: benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, di-n-butyl phthalate, and fluoranthene.

- Seven samples were analyzed for pesticides and PCBs. Arochlor-1248 was the only PCB detected in any of these samples (one sample). The sample concentration exceeded the CV. No pesticides were detected in the samples.
- Fifty-nine samples were analyzed for various metals. Antimony was detected at concentrations above the ATSDR CV in 10 of 15 samples analyzed for this contaminant. The maximum value was 52 ppm in a surface soil sample from pond 51. The other samples with antimony concentrations above the CV were taken from the saturated zone depths of ponds 39 and 42; surface soils of ponds 49A, 49C, and 48; and subsurface soils taken from pile 2. Pile 2 contains dredged soils from several of the ponds located in the southern portion of the main production area.
- Arsenic was detected at concentrations above the CV in 48 of the 59 samples. The maximum concentration detected was 340 ppm arsenic in soil from the saturated zone of pond 42. Arsenic was detected at concentrations above the CV in all but the following pond/pile locations: dredged soil from pond 39 (pile 1); ponds 44A, 44B, 45, 48, and 52; and soil from the former dredged material pile location (pile 4).
- Cadmium was detected in 54 of the 59 samples; 47 of these samples showed concentrations above the CV (10 ppm). The maximum concentration was 66 ppm in a subsurface sample taken from pond 39 (from the saturated zone). Concentrations of cadmium were below the CV or not detected in the following locations: piles 1 and 4 and ponds 44a, 44b, 48, and 52.
- Chromium was detected in all but one of the 59 samples. Only one sample, however, slightly exceeded the CV for chromium (200 ppm) and came from the surface soils of pond 48. This sample contained 226 ppm chromium.
- Lead was detected in all 59 pond/pile samples; however, only two samples had concentrations exceeding the ATSDR CV. Surface soils from ponds 48 and 49C had 900 and 440 ppm lead, respectively. Previous composite depth samples from these ponds taken in December 1989 showed lower concentrations of lead (i.e., 14.5 ppm in pond 48 and 70.5 ppm in pond 49C).
- Thallium was detected in 32 of 42 samples analyzed for this metal; 31 of these samples had concentrations exceeding the ATSDR CV (4 ppm). The maximum concentration was 37 ppm, and was found in a subsurface soil sample from pile 2 in April 1989 (depth: 8 feet). Surface soils taken from this pile during the same sampling effort showed similar

concentrations of thallium (28 and 32 ppm). A previous subsurface soil sample taken from this pile in January 1988 also tentatively showed a concentration of 31 ppm at a depth of 15 feet.

- Fluoride was detected in all 32 samples analyzed for this contaminant. Four of these samples had concentrations that exceeded the ATSDR CV for sodium fluoride (3,000 ppm). The maximum concentration (410,000 ppm) was found at the saturated zone of pond 39. The remaining three fluoride concentrations that exceeded the CV were significantly less than the maximum. One sample measured 5,280 ppm and was a composite sample from several depths of pond 45. The CV was also exceeded in composite samples from ponds 49A and 49C (3,170 and 3,120 ppm, respectively).
- Chloride was detected in more than half of the samples analyzed for this contaminant. Cyanide was detected in few samples, and all measured concentrations were less than the CV. Twenty-seven samples were analyzed for total phosphorus.
- In December 1989 and in June 1991, borings were obtained from several pond locations to determine the presence of elemental phosphorus. Elemental phosphorus was found in borings from ponds 44A, 44B, 47, 48, 49D, and 50 in December 1989 at depths ranging from 3.5 to 14.8 feet below ground surface (bgs). The maximum concentration of total phosphorus was 121,000 ppm in surface soils taken from pond 49D. In June 1991, elemental phosphorus was found in three areas next to ponds 46B and 47 at depths ranging from 10 to 24 feet bgs. This area is where waste drums containing roaster fines (i.e., calcined phosphate sand, elemental phosphorus, and sandy clay/water) were formerly buried (NUS 1989).
- Thirty-two samples were analyzed for radium-226. The ATSDR CV (5.4 Bq/kg) was exceeded in 30 of these samples. The maximum concentration of radium-226 was 1,258 Bq/kg in two composite samples taken from several depths of ponds 44A and 45. Only two samples from the lower depths of ponds 39 and 47 contained radium-226 below the detection limit.

Most of the maximum concentrations of contaminants detected in the pond soils were found in surface samples. The contaminants most frequently at levels detected above available ATSDR CVs were several SVOCs (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, and fluoranthene), several metals (antimony, arsenic, cadmium, lead, and thallium), fluoride, and radium-226. The following metals were detected in at least 50% of the samples, but were all below the respective ATSDR CV: aluminum, barium, beryllium, copper, iron, manganese, mercury, nickel, selenium, silver, vanadium, and zinc. Few VOCs/SVOCs and pesticides/PCBs were detected; of those detected, most were at levels below their respective CVs.

Overall, soils sampled in the ditch indicated little contamination (NUS 1989). No VOCs or SVOCs were detected in the one sample analyzed for these contaminants. One sample (taken closest to the cove) had a sodium concentration (20,000 ppm) that was slightly higher than the maximum found in the pond soils or other on-site surface soils (on-site surface soil results are

discussed later in this section). The remaining metals and other inorganics analyzed in the samples were either not detected or detected at concentrations below the respective CVs and below the maximum concentrations found in the pond soils and other on-site surface soils. The three ditch soils were also analyzed for gross alpha and beta radiation; in all three, levels of radiation measured were within the readings found for other on-site surface soils.

C.1.1.2. Slag (On-Site)

The following soil sampling programs were conducted as part of site investigations and include analyses of slag material taken from the slag pits and slag storage area. The soil sampling locations are shown in Figure 4. Not all of the samples obtained for each study were analyzed for the same contaminants.

- In November 1989, PBS&J conducted a radiologic evaluation of the site. PBS&J performed an EGR survey of several areas of the site, including the slag storage area in the North property. The surface and subsurface soils were also analyzed for the presence of radium-226 (PBS&J 1990). This study is documented as part of the *Site Soil Characterization Study* (Weston 1990b).
- Between December 1989 and April 1990, Weston was contracted to perform soil sampling activities at the site. Two surface soil samples from the slag pits and four surface soil samples from the slag storage area were analyzed for arsenic, cadmium, chromium, lead, cyanide, fluoride, chloride, and total phosphorus. One of the slag pit samples and six additional surface soil samples from the storage area were analyzed for radium-226 (Weston 1990a). This study is documented as part of the *Site Soil Characterization Study* (Weston 1990b).
- In March 1993, Weston analyzed one surface soil sample taken from the slag pit area. This sampling was performed as part of the RI. The sample was analyzed for TAL metals, cyanide, fluoride, phosphorus, and TCL VOCs, SVOCs, pesticides, and PCBs (Weston 1993).
- In September 1997 Parsons conducted a study to determine the extent of contaminant leaching from soil and slag in the slag storage area. A field radiation survey was conducted over the entire slag storage area. Three slag samples were then taken from areas with the highest radiation readings and analyzed for TAL metals, other inorganics, and radionuclides. These samples were also analyzed by the synthetic precipitation leaching potential (SALP) protocol (Parsons 1997).
- In July 1998, EPA Region 4 conducted a survey of several off-site materials containing slag. As part of this study, one sample from the on-site slag pile was taken for the purposes of microscopically fingerprinting the community slag materials to the Stauffer slag. This on-site sample was analyzed for the following metals and other inorganics: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper,

iron, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, zinc, fluoride, and radium-226 (EPA 1999a).

Table 3 in Appendix B summarizes the findings of the on-site slag studies. This table excludes data obtained from the slag-containing road materials. The on-site road material data are discussed at the end of this section.

Highlights of the Table 3 data summary are presented below:

- Only one sample (from the slag pit) was analyzed for VOCs, SVOCs, pesticides, and PCBs. No VOCs were detected in the sample. Benzo[a]pyrene was detected at 0.11 ppm, which is slightly above the ATSDR CV. An additional ten SVOCs and four pesticides/PCBs were detected in the sample at concentrations below the CV.
- Arsenic was detected in only 2 of the 11 samples analyzed for this contaminant. One of these samples (collected from the slag pit) contained arsenic at a concentration (4.2 ppm) that exceeded the CV.
- Cyanide was detected in 7 of 10 samples at a maximum concentration of 6.5 ppm. Fluoride and total phosphorus were detected in all 11 samples analyzed; the maximum concentrations were 1,920 and 48,500 ppm, respectively. The maximum concentrations for all three contaminants were found in samples taken from the slag storage area.
- Only one sample (from the slag storage area) was analyzed for gross alpha and beta radiation. This sample showed concentrations of 9,990 and 4,590 Bq/kg, respectively. All 12 samples analyzed for radium-226 had concentrations exceeding the CV. The maximum radium-226 concentration was 2,730 Bq/kg in a sample taken from the slag storage area.

Thirteen metals were detected in at least 50% of samples analyzed: aluminum, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, vanadium, and zinc. These were all detected below the respective CVs.

One study examined on-site road materials that were constructed from the slag. This study collected two samples of roadbed material at a depth of 1 foot and another at a depth of 4 feet (Weston 1993). All of these samples were obtained from the roadway along the western border of the site. These samples were analyzed for metals, cyanide, fluoride, total phosphorus, and radionuclides. The findings are summarized below:

- The road samples contained arsenic at concentrations ranging from 0.54 to 4.1 ppm, which are above ATSDR's CV.
- Several other metals were detected at higher concentrations in some or all of the road samples when compared with the slag samples discussed previously. All three road samples contained elevated concentrations of calcium (113,000–128,000 ppm),

magnesium (1,670–1,870 ppm), potassium (862–2,340 ppm), selenium (0.98–2.8 ppm), and sodium (1,610–1,990 ppm). In addition, the 4-foot sample contained higher concentrations of mercury (0.14 ppm), thallium (1.3 ppm), and zinc (281 ppm). Finally, one of the 1-foot samples and the 4-foot sample contained between 1.5 and 1.6 ppm silver. The remaining metals, as well as the cyanide, fluoride, and total phosphorus concentrations were within the ranges detected for the slag.

- The gross beta radiation levels detected in the road materials were above those detected in the slag sample discussed previously. These levels ranged from 7,220 to 7,896 becquerels/kilogram (Bq/kg). The gross alpha radiation and radium-226 levels were below those of the slag samples.
- The road materials were also sampled for radon-222 (1,140–1,200 Bq/kg) and polonium-210 (818–1,820 Bq/kg). The polonium-210 concentrations exceeded ATSDR's CV (210 Bq/kg).

C.1.1.3. Surface Soil

The following soil sampling programs were conducted as part of site investigations and include analyses of on-site surface soils material taken from locations around the site. These data exclude soils previously discussed (those taken from the former ponds, from dredged pond material, and samples obtained from the slag pits and slag storage area). Figure 1 in Appendix A shows the layout of the Stauffer site. Not all of the samples obtained for each study were analyzed for the same contaminants.

- In January 1988, NUS Corporation collected one surface soil sample from a wooded area on the northeast property. This sample was used to establish background surface soil conditions and analyzed for EPA CLP organics and inorganics (NUS 1989).
- In April 1989, NUS Corporation collected an additional two surface soil samples from the wooded area on the northeast property. These samples were used to establish background surface soil conditions and were analyzed for aluminum, calcium, chromium, iron, lead, and manganese (NUS 1991).
- In November 1989, PBS&J conducted a radiologic evaluation of the site. PBS&J performed an EGR survey of several areas of the site. In addition, six surface soils were analyzed for the presence of radium-226 (PBS&J 1990). This study is documented as part of the *Site Soil Characterization Study* (Weston 1990b).
- Between December 1989 and April 1990, Weston was contracted to perform soil sampling activities at the site. Fifty-two surface soil samples from various locations on the site were analyzed for arsenic, cadmium, chromium, lead, cyanide, fluoride, chloride, and total phosphorus. Twenty-three surface soils were analyzed for radium-226 and 16 were analyzed for VOCs, SVOCs, pesticides, and PCBs (Weston 1990a). This study is documented as part of the *Site Soil Characterization Study* (Weston 1990b).

- In September 1990, Weston performed additional sampling of three surface soils from one location previously sampled in December 1989. These samples were analyzed for radium-226 (Weston 1990c).
- In March 1993, Weston analyzed seven surface soil samples for TCL VOCs and SVOCs; 12 samples for TCL pesticides and PCBs; 14 samples for TAL metals; 18 samples for cyanide, fluoride, total phosphorus; and one sample for radionuclides. This sampling was performed as part of the RI (Weston 1993).
- In September 1997, Parsons conducted a study to determine the extent of contaminant leaching from soil and slag in the slag storage area. Six surface soil samples were obtained from three areas of the site and analyzed for the TAL metals, other inorganics, and radionuclides. Three of these samples were also analyzed by the SALP protocol (Parsons 1997).
- In May 1999, Parsons conducted sampling of 18 surface soils from various undisturbed locations on the site to establish background concentrations of arsenic and beryllium (Parsons 1999).

Table 4 in Appendix B presents a summary of the on-site surface soil data. Thirteen contaminants exceeded their respective CVs in the surface soils: benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, dibenzo[a,h]anthracene, indeno[1,2,3-cd]pyrene, antimony, arsenic, cadmium, iron, thallium, vanadium, fluoride, and radium-226. One sample from the southeast property was also analyzed for polonium-210, which exceeded the CV. The maximum concentrations found in the other on-site surface soils were primarily from parts of the main production area and the northeast property. Interestingly, two of the samples with maximum contaminant concentrations were from undisturbed portions of the site and were intended to establish background concentrations of contaminants in the on-site surface soils.

The main contaminants of concern were arsenic, cadmium, thallium, fluoride, and total phosphorus. These include contaminants that were detected most frequently above ATSDR CVs and/or by the greatest margin (e.g., arsenic, cadmium, and thallium), as well as those associated with site operations (e.g., fluoride, total phosphorus) in the on-site surface soils.

Highlights of the Table 4 data summary follow:

- Ten VOCs were detected in at least one of the 22 samples analyzed; none of these concentrations exceeded the ATSDR CV. Methylene chloride was the only VOC detected in more than 50 % of the samples.
- Twenty-nine SVOCs were detected in at least 1 of the 24 samples analyzed for various SVOCs. Two locations within the main production area and one location in the northeast property consistently showed concentrations exceeding the CV for the following contaminants: benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, dibenzo[a,h]anthracene, and indeno[1,2,3-cd]pyrene.

- Benzo[a]anthracene was detected at concentrations above the CV (0.87 ppm) in four of the samples. The maximum concentration was 2.9 ppm in a sample collected from the eastern portion of the main production area of the site (near the railroad track). Another sample from the same location also slightly exceeded the CV (0.88 ppm). The remaining two surface soil samples that contained elevated concentrations of this contaminant were collected from the main production area (between the water tower and railroad track) and northeast property (near pond 39).
- Benzo[a]pyrene was detected at concentrations exceeding the CV in six surface soil samples and indeno[1,2,3-cd]anthracene exceeded the CV in four samples. The maximum concentrations were 2.7 ppm benzo[a]pyrene and 3.1 ppm indeno[1,2,3-cd]anthracene. Both of these maximum concentrations were in one sample from the main production area (between the water tower and railroad track).
- The CV was exceeded for benzo[b]fluoranthene in four samples. The maximum concentration was 4.3 ppm. Dibenzo[a,h]anthracene was detected in only 3 of the 23 samples that were analyzed; however, all three of these samples contained concentrations that exceeded the CV. The maximum concentration was 0.34 ppm. Both of these maximum concentrations were found in a sample from the northeast property (near pond 39).
- Five pesticides/PCBs were detected in the 28 samples analyzed; however, each of these contaminants was found in less than 25% of these samples. The most frequently detected contaminant was a pesticide (p,p-DDT), detected in six of the samples. The maximum concentration was 0.013 ppm obtained in a composite surface soil sample taken from the eastern portion of the northeast property. The maximum concentration of p,p-DDT is well below the CV (2 ppm).
- Ninety-one samples were analyzed for various metals. Antimony was detected above the ATSDR CV in four of 21 samples analyzed for this contaminant. The maximum value was 48.9 ppm in a surface soil sample from the main production area of the site (near the railroad track between the clarifier and the road along the western border). Another sample from this same location also had an elevated concentration of 32.3 ppm. The remaining two samples with antimony concentrations above the CV were taken from the main production area (between K.V.A. substation and pond 42) and the northeast property (near pond 39).
- Arsenic was detected above the CV in 30 of 91 samples. The maximum concentration detected was 140 ppm in soil from an area near pond 39 in the northeast property. This sample also showed the maximum concentration found for cadmium (59 ppm), which also exceeded the CV. Cadmium was detected in 45 of the 73 samples; seven of these samples showed concentrations above the CV. The mean detected concentration for cadmium was 8.0 ppm.

- Only two samples were obtained in which arsenic was detected at concentrations below the CV (arsenic was not detected in 59 samples). These two samples were both taken from a relatively unused location in the northeastern portion of the main production area. Both of these samples were analyzed to determine background concentrations of arsenic in the surface soils on-site. The mean detected concentration for arsenic was 20 ppm.
- Iron was detected in all 17 samples analyzed for iron. Concentrations in two of these samples exceeded the CV for iron (23,000 ppm) and came from the surface soils in the main production area (one between K.V.A. substation and pond 42 and one between the clarifier and the road along the western border). Both of these samples showed similar concentrations that were the highest detected (between 42,900 and 44,800 ppm).
- Thallium was detected in 9 of 21 samples analyzed for this metal; four the samples had concentrations exceeding the ATSDR CV (4 ppm). The maximum detected concentration was 15 ppm; this concentration was found in the northeast property near pond 39. The remaining three samples containing elevated concentrations of thallium were obtained from the main production area (near the railroad tracks between the clarifier and the road along the western border) and the northeast property. The mean detected concentration of thallium was 6.4 ppm.
- Vanadium was detected in all 15 samples analyzed. The maximum concentration was found in a surface soil sample from the main production area (between the clarifier and the road along the western border); this concentration slightly exceeded the CV (200 ppm). The maximum concentration of vanadium was 252 ppm.
- Fluoride was detected in 75 of 77 samples analyzed for this contaminant. Only one of these had a concentration that exceeded the ATSDR CV. The maximum concentration (4,230 ppm) was found in a surface soil sample from a central location in the main production area of the site. The mean detected concentration of fluoride was 474 ppm.
- Seventy-six samples were analyzed and contained phosphorus (as total phosphorus). The maximum concentration of total phosphorus was 84,800 ppm in surface soils taken from the eastern portion of the main production area of the site (near railroad track). The mean detected concentration of total phosphorus was 24,600 ppm.
- Seven samples were analyzed for gross alpha and beta radiation. These samples showed concentrations of between 77 and 29,800 Bq/kg gross alpha radiation and between 67 and 17,800 Bq/kg gross beta radiation.
- All 39 samples analyzed for radium-226 had concentrations exceeding the CV. The maximum radium-226 concentration was 1,813 Bq/kg in a sample taken in December 1989 from an area in the northwestern portion of the main production area. A subsequent sampling effort obtained three more samples from this location less than a year later (Weston 1990c). The radium-226 concentrations in the 1990 sampling were significantly less, ranging from 67 to 100 Bq/kg.

- One sample from along the southwestern corner of the site (in the southeast property) was also analyzed for polonium-210 and radon-222 (this was the only on-site surface soil analyzed for these radionuclides). The polonium-210 concentration (7,522 Bq/kg) greatly exceeded the CV (200 ppm).

The following SVOCs and metals were detected in at least 50% of the samples, although the concentrations did not exceed the CV: benzoic acid, chrysene, di-n-butyl phthalate, fluoranthene, pyrene, aluminum, barium, beryllium, chromium, cobalt, copper, lead, manganese, nickel, selenium, and zinc.

C.1.1.4. Subsurface Soil

The following soil sampling programs were conducted as part of site investigations and include analyses of on-site subsurface soils taken from several locations around the site. These data exclude soils previously discussed (those taken from the former ponds, dredged pond material, and surface soils obtained from the slag pits and slag storage area). Figure 1 in Appendix A shows the layout of the SCC site. Not all of the samples obtained for each study were analyzed for the same contaminants.

- In January 1988, NUS Corporation collected 18 subsurface soil samples from several locations on the site. These samples were analyzed for EPA CLP organics and inorganics (NUS 1989).
- In November 1989, PBS&J conducted a radiologic evaluation of the site. PBS&J performed an EGR survey of several areas of the site. In addition, 12 subsurface soil samples were analyzed for radium-226 (PBS&J 1990). Samples were collected from two depths at six areas of the site. This study is documented as part of the *Site Soil Characterization Study* (Weston 1990b).
- Between December 1989 and April 1990, Weston was contracted to perform soil sampling activities at the site. Fifty-one subsurface soil samples from various locations on-site were analyzed for radium-226 (Weston 1990a). This study is documented as part of the *Site Soil Characterization Study* (Weston 1990b).
- In September 1990, Weston performed additional sampling of 35 subsurface soils from various locations previously sampled in December 1989. These samples were analyzed for arsenic, cadmium, chromium, lead, cyanide, fluoride, chloride, and total phosphorus. Thirteen samples were analyzed for radium-226 (Weston 1990c).
- In March 1993, Weston analyzed two subsurface soil samples for TCL VOCs, SVOCs, pesticides, and PCBs; eight samples for TAL metals, as well as cyanide, fluoride, and total phosphorus; and one sample for radionuclides. This sampling was performed as part of the RI (Weston 1993).

- In September 1997, Parsons conducted a study to determine the extent of contaminant leaching from soil and slag in the slag storage area. Eighteen subsurface soil samples were obtained from several areas of the site, including the slag storage area. These were analyzed for the TAL metals, other inorganics, and radionuclides. Three of these samples were also analyzed by the SALP protocol (Parsons 1997).

Five contaminants exceeded their respective CVs in the subsurface soils: antimony, arsenic, cadmium, thallium, and fluoride. More specific findings of the subsurface soil sampling are presented below:

- One subsurface soil sample taken from the saturated zone of a wooded area in the northeast property showed a slightly higher concentration of toluene (0.066 ppm, based on presumptive evidence) than the maximum measured in any of the surface soils; however, it is significantly less than the ATSDR CV for toluene (1,000 ppm).
- Two locations showed antimony concentrations that slightly exceeded the CV (20 ppm) at depths of 1.5 and 8 feet. The concentrations ranged from 22.6 to 29.3 ppm and were located near ponds 42 and 39, respectively.
- Nineteen subsurface soil samples of the 79 analyzed contained arsenic at a concentration exceeding the CV. The highest measured subsurface concentrations slightly exceeded the maximum surface soil concentration and ranged from 146 to 160 ppm. These were obtained from depths of 1.5 and 4 feet in areas near pond 39, as well as between the clarifier and the road along the western border of the property.
- Four subsurface soils contained concentrations of cadmium that exceeded the CV. These concentrations ranged from 18.6 to 78 ppm. Two of these samples contained concentrations that exceed the maximum surface soil concentration. The samples were obtained from the northeast property, near pond 39.
- One subsurface soil sample contained a concentration of magnesium that was slightly higher than the maximum surface soil concentration. This sample measured 4,500 ppm at a depth of 4 feet and was from an area between the clarifier and the road along the western border of the property. This same sample also contained a higher concentration of mercury (1.1 ppm, based on presumptive evidence); however, this concentration is well below the CV for mercury (20 ppm).
- The CV for thallium was exceeded in five subsurface soil samples taken from the main production area between the K.V.A. substation (depth: 6 feet), south of pond 42 (depth: 8 feet), and in the northeast property near pond 39 (depth: 1.5 feet). The northeast property samples contained thallium concentrations (between 15.9 and 18 ppm) that slightly exceeded the maximum surface soil concentration.
- Two subsurface samples contained fluoride concentrations that exceeded the CV and the maximum concentration measured for surface soils. These samples were both taken at a depth of 4 feet. One sample was obtained from an area between the clarifier and the road

along the western border and measured 260,000 ppm fluoride. The other sample was from the wooded area in the northeast property and measured 19,000 ppm (this sample was obtained to establish background concentrations in the subsurface soils).

Other metals tested were either not detected or detected at concentrations within the ranges generally found in site surface soils. Virtually all of the subsurface soils showed low concentrations (less than their CVs) of VOCs, SVOCs, pesticides, and PCBs.

C.1.2. Groundwater

Many groundwater investigations have been conducted at the Stauffer site over the years. Evaluating the findings of these groundwater investigations provides a better understanding of the nature and extent of groundwater contamination associated with the site, including the vertical and lateral extent of contamination. Although groundwater in the shallow aquifer beneath the site is contaminated with site-related substances (e.g., various metals, fluoride, phosphorus, sulfate, and radiologic contamination), migration off-site and to the deeper aquifer that serves as a drinking water source for some area residents does not appear to be extensive.

Studies in which groundwater was evaluated included:

- *Evaluation of Existing Waste Sludge Lagoon System (hydrogeologic investigation)* (PBS&J 1982).
- *Hydrogeologic investigation (1987)*: to conduct water level and hydraulic conductivity testing to characterize the surficial and Floridan aquifers beneath the site (Seaburn and Robertson 1988).
- *ESI (1989)*: to collect soil and water samples from on-site and off-site locations to support EPA's completion of HRS documentation. Installed groundwater monitoring wells; performed a land survey and geophysical investigation (NUS 1989).
- *NPL listing site inspection (1991)*: to augment existing data to provide the necessary data for a scoring of the site using the revised HRS (NUS 1991).
- *RI (1993)*: to confirm the results of past investigations and address identified data gaps to delineate the nature and extent of site contamination (Weston 1993).
- *SMC groundwater monitoring program (1987–present)*. To monitor seven surficial wells on a semiannual basis.
- *Baseline groundwater evaluation*: to characterize groundwater conditions up gradient (background) and down gradient (toward the river) of source areas (Parsons 1999).

- *Private well sampling (1990, 1997, 1999, and 2001)*: conducted by FDOH in support of its underground storage tank program and/or in response to requests from area residents. Thirty-six nearby wells sampled.
- *Final data evaluation report*: conducted by Black & Veatch Special Projects Corporation (Black & Veatch 2000) to independently assess groundwater contamination migration and impacts.
- *Summary of on-site and off-site groundwater investigations (2001)*: conducted by Flow Science, Inc. to capture key findings of all site-related groundwater studies (Flow 2001).

The scope and findings of these studies are detailed in the remainder of this section. SMC plans to conduct additional groundwater studies that will include expanding the monitoring well network in both the surficial and upper Floridan aquifers and re-evaluating hydrogeologic conditions (see Groundwater Hydrogeology subsection in the Natural Resource Use section) (Parsons 2002).

C.1.2.1. Monitoring Wells

The following groundwater sampling programs were conducted as part of site investigations or routine monitoring by SMC. In general, the objective of each of these programs was to measure the nature and extent of site groundwater contamination, including the potential for off-site migration. Because several sampling events were conducted by different investigators, the designation of the sampling locations has changed over the years. Table 6 in Appendix B describes the well designations used in the various studies. The data summary tables and Figure 5 in Appendix A (monitoring well locations) use the well designations from the RI.

- SMC has had a groundwater monitoring program in place since 1987. As part of this program, SMC has been testing seven surficial monitoring wells (M-1 through M-7). From 1987 through 1990, SMC sampled these wells quarterly; subsequent sampling has been on a semiannual basis. Samples collected as part of this program are analyzed for the following chemical parameters: aluminum, antimony, arsenic, barium, boron, chromium, fluoride, iron, lithium, manganese, nickel, ortho-phosphate, and sulfate. In addition, the following radiologic analyses are conducted: gross alpha and beta, radium-226, radon-222, and polonium-210. SMC submits semiannual reports with monitoring results to the Florida Department of Environmental Regulation (FDER), which oversees this monitoring program. Only samples collected for ortho-phosphate analysis are filtered as is required by the method.
- In January 1988, NUS Corporation collected 26 on-site groundwater samples as part of an ESI. Ten samples were from temporary monitor well boreholes, 4 from newly installed Floridan aquifer wells, 5 from newly installed surficial wells, and 7 from existing wells initially installed by Stauffer as part of the FDER quarterly monitoring requirements. Samples were analyzed for EPA CLP organics and inorganics, as well as radon. In addition to the monitoring wells, one on-site “industrial well” (no. 14) was sampled for

metals, cyanide, and fluoride. Samples were also collected from three public wells and three private wells (see below) (NUS 1989).

- In April 1989, NUS Corporation collected an additional 20 groundwater samples, including 16 from existing monitoring wells and 4 from nearby private wells. Samples were analyzed for TCL organics and TAL inorganics (NUS 1991).
- Between March 17 and April 22, 1993, Weston conducted the following groundwater investigation activities as part of the site RI (Weston 1993):
 - ▶ Four additional monitoring wells and five temporary well points were constructed in the surficial aquifer.
 - ▶ Groundwater samples were collected from the four new monitoring wells, the 11 existing surficial aquifer monitoring wells, and 3 existing Floridan aquifer monitoring wells (April 1993). Groundwater samples collected from the four new wells (MW93-1 through MW93-4) and existing wells (MW-1S, MW-01F, MW-9S, and MW-02F) were analyzed for TCL and TAL parameters. Newly installed well MW93-5 and the remaining monitoring wells (MW-2ES, -4ES, -5ES, -6ES, -7ES, -8ES, -7S, -10S, -3F, and -4F) were analyzed for TAL and radiologic parameters (gross alpha and beta, radon 222, polonium 210, and radium 226). All groundwater samples were analyzed for fluoride, cyanide, and total phosphorus.

On the basis of findings from the March/April 1993 investigations, the following supplemental groundwater investigation activities occurred:

- ▶ One additional monitoring well and three piezometers were constructed in the surficial aquifer.
- ▶ Groundwater samples were collected from the two background wells, the new monitoring well, and the Floridan aquifer monitoring well across the Anclote River from the site (July 1993).
- ▶ In 1998 and 1999, Parsons implemented a sampling program to establish conditions in the surficial aquifer both up gradient and down gradient (at the shoreline) from the contaminant source areas on-site. Four new surficial aquifer monitoring wells (MW-98-1 through MW-98-4) were installed to expand the existing network of on-site monitoring wells (Parsons 1999). MW-98-2 was installed as a replacement well for MW-93-3. Groundwater samples were analyzed for TAL metals, cyanide, fluoride, total phosphorus, elemental phosphorus, and radiologic parameters (gross alpha and beta, polonium-210, radium-226, and radon-222). The 1998 and 1999 samples were the only samples analyzed for “elemental phosphorus” (using gas chromatography).

Table 7 (surficial aquifer) and Table 8 (Floridan aquifer) in Appendix B summarize groundwater data sampled from on-site monitoring wells and two monitoring wells southwest of the site on the other side of the Anclote River (MW-11S and MW-04F). No potable water supplies currently exist on site; therefore, no one is ingesting or otherwise coming in contact with groundwater beneath the site. Tables 7 and 8 present the range of contaminant concentrations detected in each aquifer during the various sampling rounds. Unless otherwise noted, the number of samples represent a unique sampling event, which includes multiple samples from individual monitoring wells. The tables also compare the maximum detected concentrations to health-based CVs.

Highlights of the groundwater monitoring well data analyses are presented below:

C.1.2.1.1. Shallow Aquifer

- ▶ The contaminants most frequently exceeding ATSDR CVS (in greater than 40%–50% of the samples) include arsenic, fluoride, and radon-222. Other contaminants exceeding ATSDR CVS in one or more samples include aluminum, antimony, boron, cadmium, chromium, iron, lead, lithium, manganese, mercury, nickel, selenium, thallium, vanadium, sulfate, gross alpha, and radium-226.
- ▶ MW93-3 (south of lagoon 5) and MW-11S were the locations of many of the maximum detected concentrations. MW93-3 appears to be within disposal materials associated with pond 42 and was replaced by MW-98-2 in 1998 (Flow 2001). The elevated hits in MW-11S, detected during the 1988 NUS study, are considered “suspect.” Sample results from subsequent samples of arsenic, fluoride, and phosphorus in this well were 10–100 times lower. Flow (2001) points out that measured concentrations of several contaminants during the 1988 NUS study exceed the highest concentrations recorded in on-site wells during the more than 10 years of groundwater sampling that have followed.
- ▶ The highest detected concentration of fluoride (71,000 ppb) was detected in MW-3ES (down gradient of the calcium fluoride deposit). Not surprisingly, calcium concentrations (up to 2,200,000 ppb) were also highest in MW-3ES.
- ▶ Total phosphorus concentrations were detected as high as 380,000 ppb down gradient of the lagoons and the calcium fluoride storage areas. “Background” phosphorus concentrations ranged from 25 ppb (MW-7ES) to 900 ppb (also in MW-7ES) (see Attachment A).
- ▶ Sulfate, analyzed only as part of the SMC monitoring program, was detected at concentrations above NSDWR in nearly 30% of tested samples. The maximum concentration (2,400,000 ppb) was detected in the MW-7ES (background); this results appears to be anomalous, however—sulfate was detected well below NSDWR in the nearly 40 other samples tested from MW-7ES. Other locations in which sulfate detections exceed NSDWR were primarily MW2-ES on the

northeast property and MW-8ES (southeast of the ponds in the main production area).

- ▶ Radon-222 was detected at concentrations above its CV (EPA's MCL of 300 pCi/L) in 47% of the samples, with up to 11,600 pCi/L detected in MW-3ES. "Background" concentrations reported in the surficial aquifer were on the order of 1,000 pCi/L.

C.1.2.1.2. Floridan Aquifer

- ▶ Because only two Floridan aquifer wells are at or near source areas (MW-2F and MW-3F) and because these wells have only been sampled three times (1988–1993), it is not possible to draw firm conclusions about the groundwater quality in the deeper aquifer.

Two other Floridan aquifer monitoring wells are in the site area—MW-1F and MW-4F. MW-1F is designated as background and MW-4F is south of the Anclote River. Interestingly, the highest concentration of many of the metals (including arsenic) and gross alpha were detected in MW-4F (1988). However, as mentioned previously, the 1988 NUS data are considered suspect.

- ▶ Few detected concentrations of contaminants exceeded ATSDR CVS in tested wells in the Floridan aquifer. Site-related contaminant concentrations were generally lower in the Floridan aquifer compared with the surficial aquifer, although similar concentrations of arsenic and fluoride were reported in nested wells MW-9S and MW-3F, which are on the river shore down gradient of the main production area.
- ▶ The highest concentration of radon-222 (2,536 pCi/L) was detected in MW-1F (designated "background").
- ▶ One additional Floridan well not included in any of the summary samples is IW-01 (a Stauffer industrial well) was sampled in 1988 for metals, cyanide, and fluoride. All detections were below ATSDR CVS.

To more closely study the possible relationship between site-related contaminants in the surficial and Floridan aquifers, ATSDR looked at the sampling results of the few "nested" wells (i.e., wells in the same location, screened in both the surficial and Floridan aquifers). ATSDR also studied the lateral extent of contamination by evaluating groundwater quality in perimeter wells (east, west, and south of source areas) and in the wells designated "background" (i.e., to the north/northeast of source areas). The contaminants in these wells that were selected for further analysis were arsenic, lead, fluoride, and phosphorus. Arsenic and lead were selected because these were the two of the few constituents elevated in off-site private wells (see below). Fluoride and phosphorus were selected because they are site-related contaminants.

Generally, the sampling data alone are inadequate (too few samples and too little coverage) to demonstrate the lack of a connection between the surficial and Floridan aquifer. The ability to evaluate the possible extent of contamination migration toward the east (toward private wells) is also limited by the coverage and number of samples. MW-3F is the only well screened in the Floridan aquifer along the entire east/southeast perimeter of the site. Although SMC concluded that little if any contamination is migrating to the deeper aquifer and that the predominant groundwater flow direction is to the south/southwest, some uncertainty exists about the vertical and lateral extent of contamination. The upcoming groundwater studies are intended to fill such data gaps.

Results from the monitoring wells on the eastern perimeter of the site (MW93-2 and MW-10S/MW-3F) do indicate generally lower arsenic concentrations than those detected at or down gradient of source areas (and are comparable to arsenic background). The highest concentration of lead at the site perimeter was 57 ppb at MW93-2. Lead was detected as high as 680 ppb at or near source areas. The highest concentration of fluoride along the site perimeter was also detected in MW93-2, at 6,800 ppb; fluoride was detected up to 71,000 ppb in the main production area. MW93-2 was sampled only one time—during the RI in 1993. Total phosphorus concentrations in perimeter wells ranged from 790 to 3,000 ppb. A one-time high of 10,900 ppb total phosphorus was recorded in MW-9S (in 1993). Again, total phosphorus was detected as high as 380,000 ppb in the plant production areas (MW-8ES); total phosphorus concentrations ranged between 37 and 1,800 ppb in background wells

C.1.2.2. Plant Water Supply Wells

Sampling of the SCC facility's water supply wells was conducted periodically from 1948 to 1982 by SCC. The contaminant data for these wells are discussed in the Environmental Contamination and Other Hazards section of this document.

C.2. Off-Site Contamination

C.2.1. Soil

Several studies investigated soils, as well as road and building materials, off of the SCC site. All of the areas are accessible to the public and include public roads, private residences, schools, a recreation complex, a government building, and commercial facilities. Not all of the samples obtained for each study were analyzed for the same contaminants.

- ▶ In April 1989, NUS Corporation collected two surface soil samples from areas in front of and behind Gulfside Elementary School. These samples were analyzed for aluminum, calcium, chromium, iron, lead, and manganese (NUS 1991).
- ▶ In November 1989, PBS&J conducted a radiologic evaluation of the site. As part of this evaluation, PBS&J performed an EGR survey of a commercial property across the southeastern fence line. In addition, one surface soil sample and two subsurface samples

from this location were analyzed for the presence of radium-226 (PBS&J 1990). This study is documented as part of the *Site Soil Characterization Study* (Weston 1990b).

- ▶ In July 1993, Weston analyzed four surface soil samples obtained from the Gulfside Elementary School for TAL metals, cyanide, fluoride, total phosphorus, and radionuclides. This sampling was performed as part of the RI (Weston 1993).
- ▶ In February 1996, Weston conducted additional surface soil sampling of soils around Gulfside Elementary School as part of the RI. Ten surface soil samples were analyzed for TAL metals, cyanide, fluoride, and total phosphorus. Twelve samples were analyzed for radionuclides (Weston 1996).
- ▶ Between July and August 1997, Evans Environmental & Geological Science and Management, Inc. (EE&G) conducted surface soil sampling at Gulfside Elementary School to determine baseline phosphorus concentrations and pH levels at the school. Fourteen surface soil samples from six locations around the school were analyzed for ortho-phosphorus and total phosphorus. Twenty surface soil samples (coinciding with the Weston 1996 sampling locations) were analyzed for the presence of asbestos (EE&G 1997a).
- ▶ In September 1997, EE&G conducted additional sampling of construction materials used at Gulfside Elementary School that were believed to contain slag from the Stauffer site. In this study, four soil samples from beneath roadways around the school property were analyzed for radionuclides. In addition to these, samples of the roofing material and asphalt were also analyzed for radionuclides (EE&G 1997b).
- ▶ Between July 1997 and March 1998, the FDOH Bureau of Radiation Control conducted investigations at 25 off-site locations in the surrounding community in response to citizen concerns about the existence of slag material in their buildings and/or driveways. These locations consisted of residences, commercial properties, a recreational complex, and a school (not Gulfside Elementary School). Most of these investigations involved examination of EGR emitted from the materials. Soil, driveway, and roadway materials from two locations were also sampled for radium-226 (FDOH 2002).
- ▶ In July 1998, EPA Region 4 conducted a survey of several materials containing slag located off-site. As part of this study, one sample from the on-site slag pile was taken for the purposes of microscopically fingerprinting the community slag materials to the SCC slag. Twenty-five off-site samples were analyzed for the following metals and other inorganics: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, zinc, and radium-226 (EPA 1999a).
- ▶ In May 1999, Parsons conducted sampling of five surface soils from off-site fill material suppliers. These samples were analyzed for arsenic and beryllium to determine the feasibility of using these soils for future remediation activities on the site. (Parsons 1999).

C.2.1.1. Gulfside Elementary School

Table 11 in Appendix B presents a summary of the surface soils analyzed from Gulfside Elementary School. Samples were analyzed for metals, other inorganics, radionuclides, and asbestos. Highlights of the Gulfside Elementary School data summary are presented below:

- ▶ Arsenic slightly exceeded the CV (0.5 ppm) in 1 sample of the 14 analyzed. This sample was obtained from the front yard of the school and measured 0.6 ppm arsenic. Another eight samples showed concentrations of arsenic below the CV, ranging from 0.13 to 0.43 ppm.
- ▶ Ortho-phosphorus was detected in only 2 samples of 14 analyzed. These samples were obtained from the side of the school building/patio and the back fields, measuring 6.9 and 7.3 ppm ortho-phosphorus, respectively.
- ▶ Radium-226 was measured above the CV (5.4 Bq/kg) in all 15 samples analyzed. The maximum concentration was detected in the front yard sample and measured 59.2 Bq/kg. The asphalt on the roads around the school, as well as the roofing material, also contained radium-226 above the CV, as did the soils beneath the roads. The concentrations in the asphalt, roofing material, and soils were 6.7, 12, and between 45.5 and 73.6 Bq/kg, respectively.
- ▶ The soils beneath the roads also showed higher concentrations of radon-222 when compared with the maximum SCC surface soil concentration. These concentrations ranged from 73.3 to 77.0 Bq/kg.
- ▶ The Gulfside Elementary School building materials sampled (e.g., asphalt, roofing material) contained far lower concentrations of the contaminants found in the on-site slag material.

C.2.1.2. Other Off-Site Soils

Several other locations in the community surrounding the SCC site were examined, mostly in response to citizen concerns that slag material was used in the construction of their homes, driveways, and roadways. Highlights of the off-site data summary are presented below:

- ▶ The surface soil from six locations in July 1998 contained concentrations of arsenic that were higher than the CV, ranging from 0.612 to 4.85 ppm. Arsenic was detected in 26 of the 31 samples analyzed. The highest concentrations were in the pavement and road base materials of Bluff Boulevard. The Bluff Boulevard arsenic concentrations were similar to the maximum concentrations in the on-site slag material. The remaining metals analyzed in this study all were below the respective CVS (EPA 1999a).
- ▶ In May 1999, five off-site locations that store fill material used by several surrounding communities were sampled for arsenic and beryllium. Arsenic was not detected in any of

the samples. Beryllium was detected in four of the samples, with concentrations ranging from 0.08 to 0.14 ppm (Parsons 1999). The purpose of this study was to determine the feasibility of using these resources in future site remediation activities.

- ▶ All 29 samples analyzed for radium-226 showed concentrations above the CV, ranging from 8.29 to 2,600 Bq/kg. These concentrations were all below the maximum in the on-site slag material. The maximum concentrations were found in road material obtained from Bluff Boulevard and Gulfview Road. No other radionuclide was analyzed for off-site soils or building materials.
- ▶ Several other contaminants exceeded the maximum concentrations found in the slag material at the Stauffer site. These contaminants include aluminum, antimony, barium, cobalt, copper, mercury, selenium, silver, thallium, and vanadium. All of the off-site samples contained concentrations of these contaminants below their respective CVS. Several of the maximum concentrations were from the pavement and/or roadbed materials used on Bluff Boulevard, Ancloste Road, and Gulfview Road. Other samples with relatively high concentrations were from residential slab and driveway materials.

C.2.2. Groundwater

C.2.2.1. Private Wells (Off-Site)

Thirty-eight private wells (residential, commercial, and irrigation) have been sampled in the Stauffer site area since 1988. These sampling events consisted of the following:

- ▶ NUS Corporation collected six off-site groundwater samples as part of EPA's ESI in 1988. These samples were from private and public wells within a 4-mile radius of SCC (NUS 1989). Samples were analyzed for metals, cyanide, fluoride, gross alpha and beta radiation, and radon-222.
- ▶ The FDOH/Pinellas County Health Department collected and analyzed samples from private wells near the site in 1990, 1997, 1999, 2000, and 2001. Sampling was triggered in combination by Florida's SuperAct Underground Storage Tank Program and individual resident requests for follow-up sampling. Most samples were analyzed for selected VOCs/SVOCs (methyl tertiary-butyl ether, naphthalene, bis(2-ethyl hexyl)phthalate, and chloroform), metals, fluoride, chloride, sulfate, nitrate/nitrite, and radiologic parameters (gross alpha and beta radiation, radium-226, and radium-228).

The sampling data for the residential, commercial, and irrigation wells is summarized in Tables 13, 14, and 15 (Appendix B), respectively. Specific findings from the private well sampling events are highlighted below.

C.2.2.1.1. Residential Wells

- ▶ Trace concentrations of VOCs and SVOCs were detected in residential wells, with only bis(2-ethylhexyl)phthalate (detected up to 7.6 ppb) exceeding its ATSDR CV (3 ppb).
- ▶ Of the metals detected above ATSDR CVS, arsenic and lead were the most frequently detected. The remaining metals were detected at concentrations below or within the same order of magnitude of CVS.
- ▶ Arsenic was detected below its enforceable drinking water standard (10 ppb) in all but one sample with a concentration of 24 ppb (well 16, northwest of the site). All reported concentrations exceeded ATSDR's CREG for arsenic (0.02 ppb). Background concentrations of arsenic have not been well defined in the Floridan aquifer. The only up gradient monitoring well in the deeper aquifer (MW-1F) showed arsenic as "not detected" (less than 1.2 ppb) during the RI. Earlier samples from that well (1988 and 1989) also indicate no detection of arsenic, but detection limits are not reported.
- ▶ Lead was detected in 24 of the 38 samples, but only 4 samples had concentrations exceeding the CV for lead. The highest detected concentration (270 ppb) was detected in a well south of the river (well 14). The same well was tested four other times within a year's time, with lead reported at concentrations between 1.2 and 4.6 ppb. The next highest concentration (160 ppb) was detected in another well south of the river (well 10), but the well was sampled only once. Other wells tested on the same street, however, had lead concentrations ranging from 0.12 to 4.6 ppb. The remaining two samples only slightly exceeded the CV for lead.
- ▶ Only 1 of the 36 samples tested detected radiologic contamination exceeding an ATSDR CV. Gross alpha radiation was detected in 2000 sampling at 26.2 ± 5 pCi/L in well 11 south of the Anclote River.

C.2.2.1.2. Commercial Wells

- ▶ Trace concentrations of VOCs and SVOCs were detected in potable wells; only bis(2-ethylhexyl)phthalate (detected up to 4.4 ppb) exceeded its ATSDR CV (3 ppb) in one commercial well east of the site (well 3).
- ▶ Arsenic was the only metal detected at concentrations that consistently exceeded its CV. However, arsenic was only detected in two samples at concentrations exceeding its drinking water standard—both from wells east of the site (wells 2 and 8). In one of these wells, arsenic was reported at 8.9 and 9 ppb during two other sampling events in the same well. The other well was sampled just once.

- ▶ Other inorganics exceeded CVS in only one or two samples (iron, nickel, thallium, zinc, chloride, and sulfate) and at concentrations less than 3 times the CV.
- ▶ Gross alpha radiation and radium-226 were detected in two samples (wells 7 and 2, respectively) at concentrations slightly exceeding their respective CVS.
- ▶ Sulfate was detected at concentrations above its CV (250,000 ppb) in two samples. Detected concentrations of 270,000 and 650,000 ppb were found in wells 3 and 27, respectively. Only 1990 and 1997 samples were analyzed for sulfate.

C.2.2.1.3. Irrigation Wells

- ▶ No VOCs or SVOCs were detected in irrigation wells.
- ▶ Of the eight irrigation wells sampled, arsenic concentrations in six samples (maximum detected concentration reported at 4.4 ppb) exceeded the ATSDR CV.
- ▶ Only two other inorganics exceeded their respective CVS (zinc and chloride) by less than two times.
- ▶ No radiologic parameters exceeded CVS in the irrigation wells tested. Natural uranium was analyzed for in two irrigation wells and detected at a maximum concentration of 0.3 ± 0.5 pCi/L, which is substantially below the CV.²

C.2.3. Surface Water (Anclote River)

For the past 15 years, the surface water around the SCC site has been monitored and tested to establish whether the site has adversely affected the quality of the water in the Anclote River. Two discrete studies were conducted as a part of site investigations in addition to ongoing semiannual monitoring conducted by SMC. Although most of the surface water was sampled from the Anclote River upstream, adjacent to, or downstream of the site, one sample was taken from a tidal lagoon adjacent to the site on the southeast shoreline (SW-05; NUS 1989). Because sampling events were conducted by different investigators, multiple sampling location designations were used over the years. Table 24 in Appendix B describes the location designations used in compiling data from the different studies. Figure 7, Appendix A shows approximate surface water sampling locations from the various studies.

- ▶ *Final ESI (NUS 1989).* The purpose of the ESI was to collect soil and water samples from both on-site and off-site locations to obtain the data necessary to support EPA's completion of HRS documentation.

²Reported as "natural uranium." ATSDR used the CV for uranium, as reported in the Final Rule for National Primary Drinking Water Regulations: Radionuclides (December 2000). MCL is 30 ppb, which "typically" corresponds to 27 pCi/L.

NUS Corporation collected and analyzed seven surface water samples from the Anclote River. Two samples were taken upstream of the site, two adjacent to the site (including one from a tidal pond connected to the Anclote River by a culvert), one in Meyers Cove, and two downstream of the site. The far upstream and downstream samples were taken to evaluate the background concentrations in the river and the Gulf of Mexico. Each sample was tested for metals, fluoride, and phosphorus concentrations.

According to investigators, the only contamination attributable to the site discovered from any of the samples was in the tidal pond (sampling location SW-05). The pond is adjacent to the site at the dredge disposal area. The location showed elevated concentrations of barium, chromium, lead, fluoride, and phosphorus (NUS 1989).

- ▶ *RI (Weston 1993).* The RI was undertaken by Weston in 1993 to confirm the results of past investigations and address specific data gaps to more fully determine the nature and extent of site contamination. From March 29 to April 4, 1993, 18 samples were collected at 12 locations (“transects” were taken at 3 of the locations) to further evaluate surface water conditions. The samples were taken from two depths (0.3 meters below the surface and 1 meter above the bottom) and pooled to avoid the surface microlayer, depths prone to contamination by sediment resuspension, and freshwater lenses. Of the 12 sample locations, 5 were upstream of the site, 2 adjacent to the site, and 5 downstream of the site. The transect samples were collected upstream of the site, adjacent to the site, and in Meyers Cove. Each transect was made up of three samples taken from the shore outward; the samples were designated A, B, and C, with A being closest to the shore.

All samples were taken at low tide and analyzed for TAL metals, fluoride, and phosphate-phosphorus. Three samples (SW-1, 7B, and 11) were also analyzed for TCL analytes including VOCs, SVOCs, and pesticides. In addition, a profile of conductivity, temperature, and depth (CTD) was taken to evaluate vertical mixing.

Weston (1993) concluded that surface water contaminant concentrations measured during the RI were consistently lower than those measured during the ESI or in the SMC monitoring discussed below; Weston attributes these differences to differences in sampling procedures. Both the ESI (NUS 1989) and SMC semiannual investigations test water on the surface, whereas the RI intended to avoid the surface and freshwater lenses by averaging samples from two depths to achieve a more representative sample and avoid concentrations of contaminants on the surface.

- ▶ *Ongoing Surficial Groundwater Monitoring Program (SMC 1987 to present).* Since 1987, SMC has sampled two locations in the Anclote River—one just upstream of the site and one in Meyers Cove. From 1987 to 1990 SMC sampled quarterly; subsequent sampling has been semiannually. This sampling is conducted in conjunction with SMC’s on-site groundwater monitoring program.

The river samples are taken at low tide upstream of the site (roughly in line with the southeastern property line approximately 75 to 100 feet from shore) and downstream (in Meyers Cove, generally taken downstream of the calcium fluoride sludge ponds, 75 to 150 feet off the north shoreline). This sample has been included with “Meyers Cove” samples in ERG’s analysis. Field measurements of temperature, water level, pH, and conductivity are taken in addition to laboratory analysis of metals, fluoride, sulfate, phosphorus, and radiologic parameters. SMC collected samples in conformance with FDEP-approved Comprehensive Quality Assurance Plan. Samples are taken biannually, once in January or February and again in July or August.

Tables 16, 17, 18, and 19 in Appendix B contain the combined surface water data for the Anclote River system (upstream of the site, adjacent to the site, Meyers Cove, and downstream of the site, respectively) from all of the above-mentioned studies. These tables list the results for substances (chemical and radiologic) that were detected at least once. ATSDR compared all measured values of contaminants in surface water with available CVS for drinking water. The use of drinking water CVS serves as a very conservative approach to screening surface water contaminants. As noted before, the Anclote River is not used as a source of drinking water, although it contains popular fishing, boating, and swimming areas.

The sampling results revealed the following:

- Of the chemical and radiologic parameters tested, only antimony, arsenic, boron, chromium, iron, lead, thallium, vanadium, fluoride, sulfate, gross alpha, and gross beta, and radium-226 were detected at concentrations that exceeded available CVS (each to varying degrees). Phosphorus/phosphate and polonium-210 (tested in upstream and Meyers Cove only) were also detected, but no CVS are available.

Calcium, magnesium, potassium, and sodium detected throughout the areas of the river tested at generally consistent concentrations. These are naturally occurring elements and essential nutrients and their presence at detected concentrations in an estuarine system would be expected. Therefore, no further discussion of these substances is provided in this section.

- Organic compounds do not appear to be an issue in the river, although only three samples were tested for organics (during the RI). Only trace concentrations of acetone and toluene, which are common laboratory contaminants, were detected.
- No distinct contamination patterns were observed across upstream, adjacent, Meyers Cove, and downstream areas. The following trends are notable:
 - ▶ *Upstream areas.* As shown in Table 16, most substances were detected at concentrations well below CVS, with the exception of antimony, arsenic, boron, fluoride, sulfate, gross alpha and beta radiation, and radium-226—where maximum detected concentrations exceeded CVS by approximately 10 to 300 times.

- ▶ Because one of the SMC data points was directly upstream of the site, many of the upstream samples and maximum detected concentrations are from the SMC data set. It is possible that the site had a greater influence on this location than on other upstream locations.
- ▶ *Areas adjacent to Stauffer.* Table 17 summarizes the concentrations of the various contaminants detected adjacent to the Stauffer site. Data represent surface water conditions in 1988 and 1993 only. No samples were taken directly adjacent to the site by the SMC during its semiannual surface water monitoring. As a result, only six sampling locations are considered in this grouping. CVS were exceeded for arsenic, chromium, iron, lead, vanadium, fluoride, and gross alpha and beta radiation. With the exception of fluoride, the maximum concentration for each of these contaminants was detected in the tidal lagoon adjacent to the site.
- ▶ *Meyers Cove.* Table 18 in Appendix B summarizes the concentrations of the contaminants detected in Meyers Cove. The SMC semiannual monitoring program took a sample just downstream of the site in Meyers Cove on a semiannual basis and, as a result, much of the Meyers Cove data are SMC data. Water collected in Meyers Cove exceed CVS for antimony, arsenic, boron, iron, fluoride, sulfate, and gross alpha and beta radiation. Detected concentrations in Meyers Cove appear to be generally consistent with those reported upstream. Note that this comparison becomes largely a comparison of SMC's "upstream" and "downstream" samples.
- ▶ *Downstream areas.* Table 19 in Appendix B summarizes the concentrations of the contaminants detected downstream of Meyers Cove. A total of nine samples, collected in 1988 and 1993, comprise the downstream grouping. The only CV exceedances were for arsenic and thallium, both detected in 1988 samples. The available data suggest that the site has not affected the water quality further down river. No sampling of downstream areas are available, however, after the RI sampling in 1993.

An elaboration of substance-specific trends in the aforementioned areas is presented below:

- ▶ *Antimony* exceeded its CV (4 ppb) in 5 of 46 samples upstream (up to 850 ppb) and 8 of 52 samples in Meyers Cove, at concentrations up to 860 ppb.
- *Arsenic* was detected at concentrations exceeding its CV in a portion of samples collected throughout the river. The maximum detected concentration was an "estimated" measurement of 500 ppb from a downstream sample analyzed in 1988; however, this was the only detection in the nine samples tested downstream. Arsenic was detected more frequently in Meyers Cove (10 of 52 times), adjacent to the site (5 of 6 times), and upstream (8 of 46 times). The next-highest concentration of 48 ppb (detected in the tidal

lagoon adjacent to the site) also represents an estimated value from the 1988 NUS sampling; all other detected arsenic concentrations were below 6 ppb. Many of the SMC measurements for arsenic were “non-detects” (with reported detection limits ranging from 1 to 30 ppb).

- *Boron* exceeded its CV of 600 ppb in all 34 samples taken upstream and all 47 taken in Meyers Cove, with maximum detected concentrations of 5,800 and 4,500 ppb, respectively. Only the SMC sampling included boron analysis; therefore, boron was not analyzed for in any of the samples taken further upstream, adjacent to, or downstream of the site.
- ▶ Chromium was detected infrequently throughout the river. It only exceeded its CV (30 ppb) in two samples, one upstream (46 ppb) and one adjacent to the site (80 ppb).
- ▶ *Iron* was detected frequently in all stretches of the river. Although detected concentrations in Meyers Cove and adjacent to the site were up to 10 times higher than those detected in upstream or downstream samples, the CV for iron (11,000 ppb) was exceeded just one time in each of these areas (14,000 and 28,000 ppb, respectively).
- ▶ *Lead*, detected in approximately half of the 32 samples tested for it in the river, was only detected in one sample (adjacent to the site) at a concentration (150 ppb) exceeding its CV (15 ppb).
- ▶ *Thallium* exceeded its CV (0.5 ppb) downstream of the site in the only two samples in which it was detected. The highest detected concentration was an estimated value of 300 ppb from a sample collected in the 1988 NUS ESI. Thallium was sampled in each section of the river, but not measured above the detection limit in any other samples.
- ▶ *Vanadium* was detected in only one location adjacent to and one location downstream of the site. The concentration adjacent to the site (370 ppb) only slightly exceeded its CV (260 ppb).
- ▶ *Fluoride* was detected throughout the river areas tested and exceeded its CV (4,000 ppb) in approximately half the samples in which it was detected. Detected concentrations did not vary greatly in different portions of the river, although no CV exceedences occurred in downstream samples.
- ▶ *Sulfate* was consistently detected at concentrations above its CV (250,000 ppb) in Meyers Cove (45 of 47 samples) and upstream of the site (34 of 34 samples), at maximum detected concentrations of 2,980,000 and 5,200,000 ppb, respectively. Only the SMC sampling included sulfate analysis; therefore, it was not analyzed for in any of the samples taken further upstream, adjacent to, or downstream of the site.
- ▶ Of the *radiologic parameters* tested, gross alpha and beta radiation were consistently detected at concentrations above CVS in samples collected throughout the river. Radium-

226, analyzed for only in SMC samples collected in Meyers Cove and upstream, exceeded the CV in nearly all samples collected in upstream areas but only once in Meyers Cove. Polonium-210 was also detected in most samples for which it was tested, just upstream of the site and in Meyers Cove.

C.2.4. Sediment (Anclote River)

C.2.4.1. Sediment Data

Four site-related studies included sampling and analysis of sediments from the Anclote River. This section includes a summary of the four major sediment studies conducted to date and their major findings. Because sediment is so closely linked with the surface water, many of the studies sampled surface water and sediment at the same time and from the same locations. As with surface water, because sampling events were conducted by different investigators, multiple sampling location designations were used across studies. Table 25 in Appendix B describes the sample designations used in compiling data from the different studies. Figure 8 in Appendix A shows sediment sample locations.

- *Final ESI (NUS 1989).* The ESI was conducted to provide necessary data for scoring using revised HRS. As part of the ESI, NUS collected 10 sediment samples from the Anclote River and a local drainage ditch.³ These samples were analyzed for metals, cyanide, fluoride, phosphorus, and gross alpha and beta radiation.
- *Listing Site Inspection (NUS 1991).* The NPL listing site inspection was conducted to obtain additional information to support scoring of the site using the revised HRS. NUS collected 14 sediment samples along the Anclote River on April 17–18, 1989. These samples were analyzed for TCL organics and metals.
- *Sediment Sampling Program (Weston 1991).* Thirteen sediment samples were taken in the Anclote River on April 4–5, 1991, to characterize sediments upstream, adjacent to, and downstream of the site. Five of these samples were collected upstream along the same bank as the site; four adjacent to the site, and four downstream; sample SED 14 was 200 yards downstream of the boat dock adjacent to Pasco County Park. Each sample was analyzed for TAL metals, fluoride, and phosphate-phosphorus.
- *RI (1993).* This study was conducted to confirm the nature and extent of site-related contamination and to fill data gaps. Sediments were collected during two sampling events (March/April 1993 and July 1993) by Spaulding Environmental Associates of Wakefield, Rhode Island. The first sampling event was similar to the previous studies in that it sampled surface sediments. From March 29 to April 4, 1993, 18 samples were taken in the river, at the same location as the surface water samples. Each sample was taken at an interval of 0–2 centimeters and analyzed for fluoride, phosphate-phosphorus, TOC, and

³The “sediment” samples from the local drainage ditch are not included in this section. Rather, these samples were compiled and described in the soil contaminants section.

grain size. Three samples (SD-1, -7B, and -11) were also analyzed for TAL organic components. The second sampling event occurred from July 26 to 29, 1993, and included twelve 12-inch sediment cores collected in Meyers Cove and other areas adjacent to the site. Samples were taken from four transects 25 to 200 feet from shore. The core samples were analyzed for metals, fluoride, phosphorus, radiologic parameters, and grain size.

Investigators indicated that most elevated metals concentrations were generally associated with higher TOC concentrations and fine-grained sediment—higher concentrations of contaminants were found in finer sediments (“ooze,” mud, sandy mud) with high organic content. Fine sediments increased with proximity to Meyers Cove. Fine sediments are generally indicative of a depositional area. If sediments are being deposited, it is likely, but not certain, that contaminants are bound to sediments and are less likely to be resuspended or transported in the tidal cycle. Such an assessment is consistent with the fact that Meyers Cove is protected, shallow, and has low tidal current speeds. Sand dominated all other locations. The bottom sediments were all at least 77% sandy material except at station SD-07A, where the grain size was clay (46%) and silt (44%) (Weston 1993).

Tables 20, 21, 22, and 23 in Appendix B summarize available sediment data from the Anclote River (upstream of the site, adjacent to the site, Meyers Cove, and downstream of the site, respectively). ATSDR examined data from the four separate studies mentioned above and compared measured concentrations of contaminants in sediment with available CVS. As noted previously, because listed CVS are those used for soil and people contact soil more frequently than sediment, CVS serve as a protective screen.

Key findings are highlighted below beginning with trends found across the river and also addressing chemical specific trends where possible:

- Of the chemical and radiologic parameters tested, only arsenic, fluoride, thallium, methylethyl ketone, toluene, radium-226, and polonium-210 were detected at concentrations above their CVS, each to varying degrees. Phosphate-phosphorus, total phosphorus, gross alpha and beta radiation, radon-222, and TOC were also detected in parts of the river but do not have available CVS.
- The following trends are notable in each specific area of the river:
 - ▶ *Upstream sediment.* Table 20 in Appendix B summarizes the concentrations of the various substances detected in the sediment upstream of the Stauffer site. In the four investigations, 18 samples were collected, although not all locations were measured for every contaminant. CVS were exceeded only for arsenic and for one fluoride sample.
 - ▶ *Adjacent sediment.* Table 21 in Appendix B summarizes the concentrations of the contaminants detected in the 18 sediment samples collected adjacent to the

Stauffer site. As with the upstream samples, CVS were only exceeded for arsenic and fluoride (in a single sample).

- ▶ *Meyers Cove sediment.* Table 22 in Appendix B summarizes the concentrations of the various contaminants detected in the sediment from Meyers Cove. Although only arsenic, fluoride, radium-226, and polonium-210 exceeded their CVS, Meyers Cove tended to have higher concentrations than any other location on the river for the majority of the contaminants including aluminum, arsenic, barium, chromium, silver, vanadium, zinc, phosphate-phosphorus, and total phosphorus. Of the samples collected in Meyers Cove, sample SC-SD-04, collected in 1988 approximately 15 feet from shore, showed the highest concentrations of multiple metals, fluoride, and total phosphorus.
- ▶ *Downstream sediment.* Table 23 in Appendix B summarizes the concentrations of contaminants detected in the sediment downstream of the site. Thallium was detected in a single sample at a concentration 1,000 times its CV. This was the only sample of sediment in which thallium was detected in the river and appears to be an anomaly. Arsenic was detected at concentrations above its CV, as it was in all other locations of the river. Downgradient sample locations near the mouth of the river indicated no elevated contaminant concentrations.
- An elaboration of substance-specific trends is presented below:
 - ▶ Taking into consideration data from every location, of all the contaminants tested, only *arsenic* was consistently detected at concentrations above its CV. Although arsenic was detected above CV in all sections of the river, samples taken both adjacent to the site and in Meyers Cove seem to have consistently higher detected concentrations and occur more frequently than either up or down stream.
 - ▶ *Fluoride* exceeded its CV in one sample at each of the upstream, adjacent, and Meyers Cove regions. The highest fluoride concentration was an estimated value from a sample upstream of the site 6 times greater than its CV. All three of the concentrations over the CV were part of the same study (NUS 1989) and were laboratory estimated quantities. With those three exceptions, fluoride concentrations in Meyers Cove are generally higher than concentrations elsewhere in the river. The 1991 sediment sampling program and 1993 RI measurements for fluoride were significantly and consistently lower than those measured by NUS for the ESI in 1989. According to investigators, if values measured away from the site area during the RI are considered background values, then those found in close proximity to the site are elevated (Weston 1993).
 - ▶ Concentrations of *phosphate-phosphorus, total phosphorus, and TOC* are highest at Meyers Cove. Although phosphorus is measured the highest and is elevated near or in Meyers Cove according to all studies, it is otherwise variable throughout the rest of the river and does not indicate a consistent pattern.

- ▶ *Gross alpha and beta radiation* are higher in Meyers Cove than other portions of the river. *Radium-226 and polonium-210* were also highest in Meyers Cove. According to Weston (1993), gross alpha and beta radiation might be expected to have a large background concentration in a high phosphorous area such as southwestern Florida. The phosphorus-bearing formations in west central Florida (Bone Valley and Hawthorn formations) could cause not only elevated phosphorus concentrations but also unusually high numbers of uranium series isotopes in surface waters all the way out to the continental shelf (Weston 1993). Concentrations of uranium series isotopes generally increase with proximity to the SCC site but are reportedly low for such a high phosphorus area (Weston 1993).

**APPENDIX D – DESCRIPTION OF COMPARISON VALUES AND OTHER
HEALTH-BASED GUIDELINES**

DESCRIPTION OF COMPARISON VALUES AND OTHER HEALTH-BASED GUIDELINES

As noted in the text of this public health assessment, ATSDR's comparison values are media-specific concentrations that are considered to be "safe" under default conditions of exposure. They are used as screening values in the preliminary identification of "contaminants of concern" at a site. The latter is, perhaps, an unfortunate term since the word "concern" might be misinterpreted as an implication of "hazard." As ATSDR uses the phrase, however, a "contaminant of concern" is merely a site-specific chemical substance that has been selected for further evaluation of potential health effects.

Generally, a chemical is selected as a contaminant of concern because its maximum concentration in air, water, or soil at the site exceeds one of ATSDR's comparison values. However, it cannot be emphasized strongly enough that comparison values are not thresholds of toxicity. While concentrations at or below the relevant comparison value might reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a comparison value would be expected to produce adverse health effects. Indeed, the whole purpose behind highly conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health problems before they become actual health hazards. The probability that adverse health outcomes will actually occur as a result of exposure to environmental contaminants depends on site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure, and not on environmental concentrations alone.

Screening values based on non-cancer effects are obtained by dividing the lowest concentrations associated with health effects found in animal or (less often) human studies by cumulative safety margins (variously called safety factors, uncertainty factors, and modifying factors) that typically range from 10 to 1,000 or more. By contrast, cancer-based screening values are usually derived by linear extrapolation from animal data obtained at high doses, because human cancer incidence data for very low levels of exposure simply do not exist, and probably never will. In neither case can the resulting screening values (i.e., EMEGs or CREGs) be used to make realistic predictions of health risk associated with low-level exposures in humans.

A description of the various comparison values that ATSDR used in this public health assessment are provided below.

Cancer Risk Evaluation Guides (CREGs) are estimated concentrations of contaminants that are expected to cause no more than one excess cancer case for every million (1×10^{-6}) persons who are continuously exposed to the concentration for an entire lifetime. These concentrations are calculated from EPA's cancer slope factors, which indicate the relative potency of carcinogenic chemicals. Only chemicals that are known or suspected of being carcinogenic have CREG comparison values. It should be noted that exposures equivalent to CREGs are not actually expected to cause one excess cancer in a million persons exposed over a lifetime. Nor does it mean that every person in an exposed population of one million has a 1-in-a-million chance of developing cancer from the specified exposure. Although commonly interpreted in

precisely these ways, the CREGs reflect only a rough estimate of population risks, which should not be applied directly to any individual.

Environmental Media Evaluation Guide (EMEGs) are estimates of chemical concentrations that are not likely to cause an appreciable risk of deleterious, noncancerous health effects for fixed durations of exposure. These concentrations factor in estimates of receptor body weights and rates of ingestion. EMEGs might reflect several different types of exposure: acute (<14 days), intermediate (15–364 days), and chronic (>365 days). These concentrations are ultimately based on data published in ATSDR Toxicological Profiles for specific chemicals.

Lowest-Observed-Adverse-Effect-Level (LOAEL) is defined as the lowest dose of chemical in a study, or group of studies, that produces statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control.

Minimal Risk Level (MRL) is defined as an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse effects (non-carcinogenic) over a specified duration of exposure. MRLs are derived when reliable and sufficient data exist to identify the target organ(s) of effect or the most sensitive health effect(s) for a specified duration within a given route of exposure. MRLs are based only on noncancerous health effects, and do not consider carcinogenic effects. MRLs can be derived for acute, intermediate, and chronic durations of exposure for the inhalation route.

National Ambient Air Quality Standards (NAAQS) are developed by EPA to protect people and the environment from unhealthy and undesirable levels of air pollution. As of the writing of this report, EPA has promulgated NAAQS for seven pollutants (known as “criteria pollutants”). These standards have been developed specifically to protect the health and welfare of humans. To be conservative, these standards were designed to be protective of exposed persons, including most “sensitive” populations (e.g., persons with asthma).

No-Observed-Adverse-Effect-Level (NOAEL) is defined as the dose of chemical at which there were no statistically or biologically significant increases in the frequency or severity of adverse effects seen between the exposed population and its appropriate control. Effects may be produced at this dose, but they are not considered to be adverse.

Risk-Based Concentrations (RBCs) are derived by Region 3 of the U.S. Environmental Protection Agency (EPA) and represent concentrations of contaminants in tap water, ambient air, fish or soil (industrial or residential) that are considered unlikely to cause adverse health effects. They are derived using conservative exposure assumptions and EPA’s Reference Doses, Reference Concentrations, or slope factors. RBCs are based either on cancer or non-cancer effects.

**APPENDIX E – BRIEF REVIEW OF PERTINENT HUMAN AND ANIMAL STUDIES
FOLLOWING BRIEF EXPOSURES TO SULFUR DIOXIDE**

A REVIEW OF HARMFUL EFFECTS OF SULFUR DIOXIDE FROM VERY SHORT EXPOSURES

This is a brief review of the most important human studies about the effects of sulfur dioxide from acute exposures. In conducting this review, ATSDR used not only its Toxicological Profile for Sulfur Dioxide but also conducted extensive searches of a national toxicological database (TOXLINE).

The most sensitive people to sulfur dioxide exposure are persons with asthma. Children with asthma might be particularly sensitive because of an inherent sensitivity or because children exercise more frequently than do adults, which increases the breathing rate resulting in more exposure to sulfur dioxide in air (ATSDR 1998). It should be noted also that exercise alone can trigger asthma attacks. If sulfur dioxide levels are high enough, children and adults who do not have asthma could also experience harmful effects. The effects of sulfur dioxide on the lungs of persons with asthma are summarized in Table 40 in Appendix B.

Sheppard et al. reported that persons with mild asthma who were exposed to 100 ppb sulfur dioxide for 10 minutes experienced an increase in airway resistance and bronchoconstriction in the lungs during moderate exercise (ATSDR 1998; Sheppard et al. 1981). An increase in airway resistance means that air traveling through the airway passages in the lungs is meeting more resistance; bronchoconstriction is the narrowing of the air passages in the lung. The increases in airway resistance and bronchoconstriction do not produce noticeable symptoms at this level of sulfur dioxide exposure and can only be measured in a clinical setting. Increases in airway resistance and bronchoconstriction are more pronounced in persons exposed to 250 and 500 ppb, and at 500 ppb, the increased airway resistance and bronchoconstriction are associated with wheezing and shortness of breath in some persons with asthma.

Similarly, Balmes et al. reported an increase in airway resistance in persons with asthma exposed to 500 ppb sulfur dioxide for 3 minutes (ATSDR 1998; Balmes et al. 1987). The resulting bronchoconstriction also resulted in wheezing, chest tightness, and shortness of breath. It is important to know that some persons with asthma had to take a bronchodilator after exposure to 500 ppb, whereas others were not able to complete the experiment because of breathing problems. Some authors report that these persons experienced pronounced wheezing and tightness of the chest, with some requesting bronchodilators to relieve the symptoms of bronchoconstriction (ATSDR 1998; Bethel et al. 1984; Koenig et al. 1985, 1993; Balmes et al. 1987; Horstman et al. 1986, 1988; Linn et al. 1984a, 1984b, 1984c; Roger et al. 1985). Numerous other human studies support the findings of these studies in causing an increase in airway resistance and bronchoconstriction in persons with asthma who are exposed to several hundred parts per billion sulfur dioxide (ATSDR 1998). In addition to persons with asthma, another sensitive group is elderly adults with preexisting respiratory or cardiovascular disease or chronic lung disease, such as bronchitis or emphysema (WHO 1979).

Persons without asthma can also experience pulmonary effects when exposed to sulfur dioxide; however, a higher level of exposure is required. Islam et al. report that persons without asthma who were exposed to 600 to 800 ppb sulfur dioxide for 5 minutes, *using a mouthpiece apparatus*, can experience an increase in airway resistance (Islam et al. 1992). It should be noted that the

600-ppb exposure group in the Islam study is an effect level; the authors did not identify a no-effect level in their study. Uncertainty exists in applying this study to the members of the public who do not have asthma because the authors used a mouthpiece to measure the delivered dose of sulfur dioxide. Using a mouthpiece might increase the amount of sulfur dioxide that enters the lungs because trapping of sulfur dioxide in the nasal passages is avoided. The levels used in this study might be more applicable to exercising persons who do not have asthma, because exercise increases breathing through the mouth rather than the nose. That levels of 600 to 800 ppb sulfur dioxide can cause an effect in persons without asthma, however, is supported by other research. Lawther et al. showed that a similar response occurred at 1,000 ppb sulfur dioxide (Lawther et al. 1975). Also at 1,000 ppb, people can experience an increase in heart rate and breathing rate (Amdur et al. 1953; ATSDR 1998). Therefore, somewhere between 600 and 1,000 ppb sulfur dioxide, persons without asthma might begin to experience lung effects.

Several human studies show additional harmful effects occurring for exposures above 1,000 ppb. The adverse effects observed included increased heart rate and breathing rate, increased number of macrophages in lung fluid, cough, irritation, redness of the airways, and increased inflammatory cells in lung fluid (Sandstrom et al. 1989; Lawther et al. 1975; Amdur et al. 1953).

Activity level and weather conditions are also a factor in whether or not sulfur dioxide can cause harmful effects. When people are at rest and breathing normally, sulfur dioxide is absorbed in the moist environment of the nasal passages and less sulfur dioxide reaches the air passages in the lung. Therefore, people at rest can be exposed to higher levels of sulfur dioxide before experiencing effects on the lung than people who are exercising. During exercise or increased activity, however, people breathe faster and are more likely to breathe through their mouth; therefore, more sulfur dioxide is likely to reach the lower air passages in the lung. These factors result in more sulfur dioxide reaching the lungs, thus causing an increase in airway resistance and bronchoconstriction. Weather also becomes a factor, because more sulfur dioxide will reach the air passages in cold, dry (low humidity) atmospheres, thus increasing the likelihood of increased airway resistance and bronchoconstriction (ATSDR 1998; Bethel et al. 1984; Linn et al. 1985; Sheppard et al. 1984).

From the information presented in Table 40 (Appendix B), 100 ppb sulfur dioxide might cause mild effects in the lungs of exercising persons with asthma from exposures as short as 3 minutes. About 10% (or 10 of every 100) children have asthma. At 100 ppb sulfur dioxide, the responses do not produce any signs or symptoms but can be measured in a clinical setting. The effects on airway resistance become more pronounced with increasing sulfur dioxide concentration to point that wheezing and shortness of breath can occur when sulfur dioxide levels reach about 500 ppb. When sulfur dioxide levels reach about 5,000 ppb, throat irritation and cough can occur along with effects that can only be detected in a clinical setting.

APPENDIX F – DEFINITIONS FOR TSP, PM₁₀, AND PM_{2.5}

DEFINITIONS FOR TSP, PM₁₀, AND PM_{2.5}

Introduction

For nearly 20 years, EPA has closely monitored the levels of solid particles and liquid droplets or aerosols, or “particulate matter,” in the air that people breathe. Many health studies have shown that the size of airborne particles is closely related to potential health effects among exposed populations (see Public Health Implications section for more details). As a result, EPA and public health agencies focus on the size of airborne particles when evaluating levels of air pollution. Over the years, particulate matter has been generally classified into three categories: TSP, PM₁₀, and PM_{2.5}; therefore, it is first important to understand the definition for these terms before describing the ability of particulates to cause harmful effects.

Total suspended particulates (TSP)

TSP refers to a wide range of solid particles and liquid droplets found in ambient air, and typically is measured as particles having aerodynamic diameters of 25 to 40 microns or less (EPA 1996). EPA’s health-based National Ambient Air Quality Standards (NAAQS) regulated ambient air concentrations of TSP until 1987; these standards required annual average concentrations of TSP to be less than 75 $\mu\text{g}/\text{m}^3$ and 24-hour average concentrations to be less than 260 $\mu\text{g}/\text{m}^3$ (EPA 1996). Many industrial, commercial, mobile, and natural sources emit TSP to the air.

Particulate matter smaller than 10 microns (PM₁₀)

PM₁₀ refers to the subset of TSP composed of particles smaller than 10 microns in diameter. With research showing that PM₁₀ can penetrate into sensitive regions of the respiratory tract, EPA stopped regulating airborne levels of TSP in 1987, and began regulating ambient air concentrations of PM₁₀. EPA continues to regulate levels of PM₁₀ today, and requires annual average concentrations to be less than 50 $\mu\text{g}/\text{m}^3$ and 24-hour average concentrations to be less than 150 $\mu\text{g}/\text{m}^3$ (EPA 1996). Typical sources of PM₁₀ include, but are not limited to, wind-blown dust, grinding operations, and dusts generated by motor vehicles driving on roadways.

Particulate matter smaller than 2.5 microns (PM_{2.5})

PM_{2.5} or “fine particulates” refers to the subset of TSP composed of particles with aerodynamic diameters of 2.5 microns or less. By definition, PM_{2.5} is also a subset of PM₁₀. With recent studies linking inhalation of fine particles to adverse health effects in children and other sensitive populations, EPA proposed regulating ambient air concentrations of PM_{2.5} in 1997. These health-based regulations require annual average concentrations of PM_{2.5} to be less than 15 $\mu\text{g}/\text{m}^3$ and 24-hour average concentrations to be less than 65 $\mu\text{g}/\text{m}^3$ (EPA 1997). Although many sources emit PM_{2.5}, the pollutant is primarily emitted by combustion sources (e.g., motor vehicles, power generation, boilers and industrial furnaces, residential heating). Fine particles are also formed in the air from other pollutants. Although EPA’s promulgation of the PM_{2.5} standard is still under legal review, ATSDR uses the proposed standard and other scientific evidence to evaluate inhalation exposures to PM_{2.5}.

**APPENDIX G – ESTIMATION OF PM_{10} AND $PM_{2.5}$ CONCENTRATIONS FROM
MEASURED TSP CONCENTRATIONS**

ESTIMATION OF PM_{10} AND $PM_{2.5}$ CONCENTRATIONS FROM MEASURED TSP CONCENTRATIONS

The only ambient air monitoring data available for the years Stauffer was operating is for TSP, and no sampling data characterized the size distribution of these particles. ATSDR prefers to base conclusions regarding exposures to particulate matter on measurements of PM_{10} or $PM_{2.5}$ concentrations, which are more predictive of adverse health effects. Because no sampling studies measured air concentrations of these particle size fractions, ATSDR investigated options for estimating the PM_{10} and $PM_{2.5}$ exposure levels.

This appendix describes how we *estimated* PM_{10} and $PM_{2.5}$ exposure levels from the TSP monitoring data, based on our knowledge of particle size distributions in the vicinity of elemental phosphorus production facilities. Important information on the uncertainty and limitations associated with this estimation is also presented.

Estimating Long-Term PM_{10} Levels from TSP Levels

PM_{10} is a subset of TSP. The relative amount of PM_{10} within TSP depends on many factors, such as the local sources of air pollution. ATSDR investigated multiple options to *estimate* the amount of PM_{10} within the TSP that was measured at the Ancote Road monitoring station. One option was to use PM_{10} :TSP ratios, based on sampling data collected in northern Pinellas County and southern Pasco County in the 1990s. Comments from peer reviewers suggested that such an approach involves considerable uncertainty, because we would be using ratios derived from a time period when Stauffer was not operating.

As an improved approach, ATSDR estimates PM_{10} levels during the time Stauffer operated using a PM_{10} :TSP ratio derived from extensive ambient air monitoring data collected near the fence-line of an active elemental phosphorus production facility in southeastern Idaho—a sampling arrangement similar to the Ancote Road monitoring station being adjacent to the Stauffer facility. At the Idaho facility, the average PM_{10} :TSP ratio, based on nearly 2 whole years of concurrent sampling, was 0.50, with a standard deviation of 0.14. ATSDR applied this average ratio to estimate annual average PM_{10} concentrations in the years for which only TSP data are available. Table 48 in Appendix B documents these results. The end of this section describes the uncertainties inherent in this approach.

Estimating Long-Term $PM_{2.5}$ Levels from PM_{10} Levels

To *estimate* the exposure concentrations for $PM_{2.5}$, ATSDR similarly applied $PM_{2.5}$: PM_{10} ratios to the estimated PM_{10} levels. We had considered using $PM_{2.5}$: PM_{10} ratios measured in St. Petersburg and other parts of the southeastern United States for this analysis, but comments from peer reviewers questioned whether such data would be representative of ambient conditions in the vicinity of an elemental phosphorus plant. Based on these comments, we decided that particle size ratios observed near the elemental phosphorus production facility a more representative of the airborne particle size distribution that occurred near Stauffer. Thus, we used the same data set identified in the previous section, which indicates that the average $PM_{2.5}$: PM_{10} ratio near the

elemental phosphorus plant was 0.6. Table 49 shows we used this factor to *estimate* PM_{2.5} concentrations in the vicinity of Stauffer based on this particle size ratio.

Uncertainty and Limitations

Since ambient air concentrations of PM₁₀ and PM_{2.5} were never measured near Stauffer while the facility operated, ATSDR could only *estimate* the airborne levels of these pollutants, and our estimates—no matter what approach we took—would involve some uncertainty. The extent of uncertainty in our PM_{2.5} and PM₁₀ estimates depends on the validity of the assumptions made in applying the ratios. The key question for this calculation is to what extent particle size ratios observed at the fence-line of one elemental phosphorus production facility are representative of ratios at the fence-line of another. While we expect the magnitude of particulate matter levels to differ considerably between the Idaho and Florida facilities (due to the differences in production levels), there is less reason to believe that the composition of various particle sizes would differ dramatically, especially considering the similarity in the production processes.

Nonetheless, ATSDR emphasizes that the PM₁₀ and PM_{2.5} exposure concentrations are *estimates* of actual air pollution levels, and they might understate or overstate actual exposures. The fact that our estimated PM_{2.5} concentrations are consistent with those predicted by our dispersion modeling analysis (see Section 5.3.2) reassures us that the concentrations estimated using the ratio approach are reasonable, though some uncertainties undoubtedly remain.

APPENDIX H – ATSDR GLOSSARY OF ENVIRONMENTAL HEALTH TERMS

ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption

The process of taking in. For a person or animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute

Occurring over a short time [compare with **chronic**].

Acute exposure

Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with **intermediate duration exposure** and **chronic exposure**].

Additive effect

A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with **antagonistic effect** and **synergistic effect**].

Adverse health effect

A change in body function or cell structure that might lead to disease or health problems.

Aerobic

Requiring oxygen [compare with **anaerobic**].

Ambient

Surrounding (for example, *ambient* air).

Anaerobic

Requiring the absence of oxygen [compare with **aerobic**].

Analyte

A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Analytic epidemiologic study

A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Antagonistic effect

A biologic response to exposure to multiple substances that is **less** than would be expected if the known effects of the individual substances were added together [compare with **additive effect** and **synergistic effect**].

Background level

An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation

Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study

A study that uses (a) **biomedical testing** or (b) the measurement of a substance [an **analyte**], its **metabolite**, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see **exposure investigation**].

Biologic monitoring

Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake

The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing

Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota

Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden

The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP

See **Community Assistance Panel**.

Cancer

Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk

A theoretical risk of for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen

A substance that causes cancer.

Case study

A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study

A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number

A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system

The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see **Comprehensive Environmental Response, Compensation, and Liability Act of 1980**]

Chronic

Occurring over a long time (more than 1 year) [compare with **acute**].

Chronic exposure

Contact with a substance that occurs over a long time (more than 1 year) [compare with **acute exposure** and **intermediate duration exposure**].

Cluster investigation

A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)

A group of people, from a community and from health and environmental agencies, who work with ATSDR to resolve issues and problems related to hazardous substances in the community.

CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

Comparison value (CV)

Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see **exposure pathway**].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)

CERCLA, also known as **Superfund**, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration

The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant

A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect

A disease or injury that happens as a result of exposures that might have occurred in the past.

Dermal

Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact

Contact with (touching) the skin [see **route of exposure**].

Descriptive epidemiology

The study of the amount and distribution of a disease in a specified population by person, place, and time.

Detection limit

The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease prevention

Measures used to prevent a disease or reduce its severity.

Disease registry

A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD

United States Department of Defense.

DOE

United States Department of Energy.

Dose (for chemicals that are not radioactive)

The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An “exposure dose” is how much of a substance is encountered in the environment. An “absorbed dose” is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)

The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship

The relationship between the amount of exposure [**dose**] to a substance and the resulting changes in body function or health (response).

Environmental media

Soil, water, air, **biota** (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism

Environmental media include water, air, soil, and **biota** (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The **environmental media and transport mechanism** is the second part of an **exposure pathway**.

EPA

United States Environmental Protection Agency.

Epidemiologic surveillance

The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Epidemiology

The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure

Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [**acute exposure**], of intermediate duration, or long-term [**chronic exposure**].

Exposure assessment

The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction

A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation

The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway

The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a **source of contamination** (such as an abandoned business); an **environmental media and transport mechanism** (such as movement through groundwater); a **point of exposure** (such as a private well); a **route of exposure** (eating, drinking, breathing, or touching), and a **receptor population** (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a **completed exposure pathway**.

Exposure registry

A system of ongoing followup of people who have had documented environmental exposures.

Feasibility study

A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS)

A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds

Training sessions for physicians and other health care providers about health topics.

Groundwater

Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with **surface water**].

Half-life ($t_{1/2}$)

The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

Hazard

A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)

The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste

Potentially harmful substances that have been released or discarded into the environment.

Health consultation

A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with **public health assessment**].

Health education

Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation

The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to estimate the possible association between the occurrence and exposure to hazardous substances.

Health promotion

The process of enabling people to increase control over, and to improve, their health.

Health statistics review

The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard

The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence

The number of new cases of disease in a defined population over a specific time period [contrast with **prevalence**].

Ingestion

The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see **route of exposure**].

Inhalation

The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].

Intermediate duration exposure

Contact with a substance that occurs for more than 14 days and less than a year [compare with **acute exposure** and **chronic exposure**].

In vitro

In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with **in vivo**].

In vivo

Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with **in vitro**].

Lowest-observed-adverse-effect level (LOAEL)

The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Medical monitoring

A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

Metabolism

The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite

Any product of **metabolism**.

mg/kg

Milligram per kilogram.

mg/cm²

Milligram per square centimeter (of a surface).

mg/m³

Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration

Moving from one location to another.

Minimal risk level (MRL)

An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects.

MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].

Morbidity

State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality

Death. Usually the cause (a specific disease, condition, or injury) is stated.

Mutagen

A substance that causes **mutations** (genetic damage).

Mutation

A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)

EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

No apparent public health hazard

A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)

The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard

A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Physiologically based pharmacokinetic model (PBPK model)

A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica

A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume

A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure

The place where someone can come into contact with a substance present in the environment [see **exposure pathway**].

Population

A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)

A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb

Parts per billion.

ppm

Parts per million.

Prevalence

The number of existing disease cases in a defined population during a specific time period [contrast with **incidence**].

Prevalence survey

The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention

Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public comment period

An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public availability session

An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public health action

A list of steps to protect public health.

Public health advisory

A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)

An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with **health consultation**].

Public health hazard

A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or **radionuclides** that could result in harmful health effects.

Public health hazard categories

Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are **no public health hazard**, **no apparent public health hazard**, **indeterminate public health hazard**, **public health hazard**, and **urgent public health hazard**.

Public health statement

The first chapter of an ATSDR **toxicological profile**. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people

might be exposed to a specific substance and describes the known health effects of that substance.

Public meeting

A public forum with community members for communication about a site.

Radioisotope

An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide

Any radioactive isotope (form) of any element.

RCRA [See Resource Conservation and Recovery Act (1976, 1984)]

Receptor population

People who could come into contact with hazardous substances [see **exposure pathway**].

Reference dose (RfD)

An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Registry

A systematic collection of information on persons exposed to a specific substance or having specific diseases [see **exposure registry** and **disease registry**].

Remedial Investigation

The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)

This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA

RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD

See **reference dose**.

Risk

The probability that something will cause injury or harm.

Risk reduction

Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication

The exchange of information to increase understanding of health risks.

Route of exposure

The way people come into contact with a hazardous substance. Three routes of exposure are breathing [**inhalation**], eating or drinking [**ingestion**], or contact with the skin [**dermal contact**].

Safety factor [see uncertainty factor]**SARA [see Superfund Amendments and Reauthorization Act]****Sample**

A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see **population**]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size

The number of units chosen from a population or environment.

Solvent

A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination

The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an **exposure pathway**.

Special populations

People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder

A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics

A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance

A chemical.

Substance-specific applied research

A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's **toxicological profiles**. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund Amendments and Reauthorization Act (SARA)

In 1986, SARA amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water

Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with **groundwater**].

Surveillance [see **epidemiologic surveillance**]**Survey**

A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see **prevalence survey**].

Synergistic effect

A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see **additive effect** and **antagonistic effect**].

Teratogen

A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent

Chemical or physical (for example, radiation, heat, cold, microwaves) agents which, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile

An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology

The study of the harmful effects of substances on humans or animals.

Tumor

An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor

Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a **safety factor**].

Urgent public health hazard

A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compounds (VOCs)

Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Other glossaries and dictionaries:

Environmental Protection Agency <http://www.epa.gov/OCEPAterms/>

National Center for Environmental Health (CDC)

<http://www.cdc.gov/nceh/dls/report/glossary.htm>

National Library of Medicine

<http://www.nlm.nih.gov/medlineplus/dictionaries.html>